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ABSTRACT

Educators today are challenged with building a communications system that promotes educational values while at the same time teaching children to cope with a chaotic information environment. This report examines how educators are grappling with the difficult interplay of technological change and educational values. It begins by reviewing the potential for technology-driven education reform. The second section outlines an agenda for building the human infrastructure of the Information Age by addressing such issues as content, curriculum reform, professional development, assessment, equity and community involvement. The third section describes some of the activities of major institutional players in the educational technology arena. In the fourth section, it discusses how the success or failure of the effort to reform schools ultimately will be decided not in Washington, D.C., corporate board rooms, or state capitals, but in individual communities all over the United States. The report concludes by listing resources for further study of this complex issue, including the materials and schools cited. (Author/AEF)

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Communications Policy and Practice

The Learning Connection

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Benton Foundation

Communications Policy and Practice

The Learning Connection

Schools in the Information Age

By Christopher Conte
with research and editorial contributions by Jon Berroya, Susan Goslee, Jillaine Smith, and Kevin Taglang

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Introduction: A national commitment

Americans are investing heavily to bring computer networking to our schools, but are we getting our money's worth?

Local school districts are spending $4 billion a year on new technology. President Clinton, as a down payment toward meeting his goal of connecting every classroom and library to the Internet by 2000, wants the federal government to kick in $2 billion over the next five years for hardware and software. In addition, the Federal Communications Commission has created a $2.25 billion annual fund to help schools and libraries pay for Internet connections.

Telephone and computer companies, meanwhile, are contributing dollars, hardware, services, and expertise to help schools get connected. And on just three "NetDays" since March 1996, thousands of volunteers have helped wire more than 30,000 schools in 40 states for Internet connections. Clearly, as the *San Jose Mercury News* put it, "If there is a Holy Grail in education today, it is computer technology."

But for all the enthusiasm, some fear that technology may simply be an expensive diversion. While researchers debate the actual effects of technology on learning, only 13.4 percent of teachers polled by the research firm Market Data Retrieval in February 1997 said they believe Internet access has yet helped students achieve better results. And the potential cost of the job of connecting schools could be substantial: a 1995 analysis by McKinsey & Co. said it could run as high as $47 billion over 10 years, plus another $14 billion in annual operating expenses.

The price tag may not seem like much compared with the more than $320 billion we currently spend on primary and secondary education each year, but it comes at a time when schools face many competing demands. Enrollments are rising, and many districts are grappling with an increasingly diverse student population. At the same time, school buildings are aging: the General Accounting Office estimates that the cost of repairing leaky roofs and performing other mundane repairs could total $112 billion. And many Americans worry that large numbers of children aren't even mastering rudimentary reading and writing skills, let alone learning how to navigate the new high-tech information byways.

Are the new technologies worth their cost in the face of these other needs? Not if they are adopted in a vacuum. Evidence strongly suggests that technology alone is no panacea. For it to work well for students and schools, we must build "human infrastructure" at the same pace we are installing computers and wiring.

Are the new technologies worth their cost in the face of these other needs? Not if they are adopted in a vacuum. Though some schools that use computer technology are achieving impressive results, many factors contribute to their overall success. Evidence strongly suggests that technology alone is no panacea. For it to work well for students and schools, we must build "human infrastructure" at the same pace we are installing computers and wiring. Specifically, we must address such issues as:

- *Content.* The Internet will be a valuable educational tool only if it is a source of high-quality, reliable, and relevant information that can be efficiently found and adapted to educational needs.

- *Curriculum reform.* We must define more clearly what intellectual skills students need, and develop better techniques for teaching them.

- *Professional development.* People have been talking for years about the need to train teachers in the use of technology. But we now realize that teachers need more than simple training; they also need support and time to develop lesson plans and to collaborate with colleagues.

- *Assessment.* We need better tools to gauge whether students are truly benefiting from new technologies. Public support for the substantial continuing investment the new tools require is unlikely to endure unless we can demonstrate that there are clear benefits.

- *Equity.* Hanging over this debate is a troubling question: what will happen if the benefits our education system might offer are not realized by all children? If technology enthusiasts are right about the potential gains from computer networking in classrooms, then an uneven distribution of technology on the basis of income, race, or geography could widen social divisions that already have grown in recent years.

- *Community involvement.* The ideal of classrooms linked to the outside world will make sense only if students can find supportive communities when they venture electronically beyond their classrooms. Technology is giving parents, businesses, nonprofit organizations, governments, and others an enormous opportunity —and responsibility—to become more involved in educating our children.

Clearly, these are concerns for more than educators alone. How we address them will go a long way toward determining whether we can build a communications system that serves public needs and promotes democratic values. At the same time, how well we teach our children to cope with today's chaotic information environment will help determine whether future generations are empowered to fully participate in the social, political, and cultural life of the nation, or whether they instead are stuck in the roles of passive consumers and spectators.

This report examines how educators are grappling with the difficult interplay of technological change and educational values. It

begins by reviewing the potential for technology-driven education reform. The second section spells out an agenda for building the human infrastructure of the Information Age. The third section describes some of the activities of major institutional players in the education technology arena. In the fourth section it discusses how the success or failure of the effort to reform schools ultimately will be decided not in Washington, D.C., corporate board rooms, or state capitals, but in individual communities all over the country. The report concludes by listing resources for further study of this complex issue, including the material and schools cited.

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High hopes, high hurdles

"Does the Tiger Eat Her Cubs?"

With that provocative question based on a Chinese proverb, a lesson plan devised by researchers at San Diego State University challenges teachers and students to launch a "web quest" exploring whether children in Chinese orphanages are being mistreated. The American students will split into teams, each of which will venture on to the Internet in search of answers. They will review reports from Human Rights Watch, read the transcript of a British television documentary, see the Chinese government's response, analyze arguments by an American journalist who fears the controversy will prompt China to close the door to more foreign adoptions, and study an article in the online journal *Asiaweek* suggesting that China's policy of limiting families to one child each is actually creating a society of "spoiled brats."

Next, after consulting an online primer on consensus decision-making, the student teams will come together to hammer out a collective judgment from this sea of information. Even then, they won't be finished. After reading *Congressional Quarterly*'s online profile of their representative in Congress, they'll express their views in email to the lawmaker and, perhaps, the president of the United States. Or, they'll send email to the editor of One World, a British website that carries reports put out by Human Rights Watch and other think tanks and nonprofit groups.

This could be the future of education. As envisioned by computer advocates and education reformers, it's a future in which the walls between the classroom and the outside world have disappeared, where children are exposed to complex, real-world issues, challenged to sift through the raw materials of the Information Age, and empowered to communicate their ideas to a global audience. In this enriched environment, the theory goes, the authenticity of what they're doing will motivate students to acquire the sophisticated thinking skills needed to live and work in the twenty-first century.

A vision for twenty-first century schools

Where it has caught on, this approach to education can be exciting. Consider these examples:

- In Mendocino, California, math students at Mendocino Middle School study linear and exponential patterns of growth by experimenting with population simulation programs they download from

Virginia Polytechnic Institute. Based on these programs, they prepare reports for state and foreign governments on the likely impact of population changes on demand for public services.

- In Cranford, New Jersey, students at Cranford High School have designed a website that details a fictitious murder case. As they describe each step of the legal process, they present detailed fact sheets explaining the underlying legal principles. By the end readers not only have been treated to an interesting story, they have also absorbed a comprehensive primer on the entire U.S. judicial system.

- In Pullman, Washington, students at Sunnyside Elementary School learn about linguistic and cultural differences by exchanging artwork with their peers overseas and discussing the results by email.

- In Boulder, Colorado, students at Centennial Middle School work with their peers at schools in three other states and Canada to produce an electronic newspaper expressing their views on contemporary issues.

In all of these cases, students are assuming more responsibility for their own education. Instead of absorbing an established body of knowledge delivered to them by teachers, they are developing skills to seek, sift, analyze, and convey information themselves. Instead of studying discrete academic subjects, they are addressing real-world concerns in an interdisciplinary way. Instead of studying in isolation, they are working on teams. And instead of merely regurgitating what they have learned back to their teachers, they are communicating their findings to a much wider public.

Source: QED's Internet Usage in Public Schools, 2nd ed., 1997

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Teachers who have embraced these methods are overwhelmingly enthusiastic about the results. Among other things, they revel in the abundant resources computer networks bring into their classrooms. Over the Internet, notes education consultant Margaret Riel, students can interact with exhibits at a museum, take a "tour" of the White House, aim a telescope into outer space, or "visit" cities around the world. They can find electronic penpals (known as "keypals") or join kids in classrooms around the world to pool data on such common concerns as water quality. They can connect with mentors outside their schools or consult with experts on everything from geology and math to classical music and fine arts. And they can follow along as scientists, explorers, and adventurers mount expeditions to earth's most remote areas.

Such real-world connections are powerful motivators for students, teachers say. "The kids are learning better," notes Bart Hays, a teacher at Morse High School in San Diego. "I'm constantly reassured every time I put them on the computers. They're so excited, and they get so much done. Their attitude toward the entire class changes."

Joyce Brunsvold, a reading teacher at Fairland Elementary School in Montgomery County, Maryland, sees a big gain in both the quality and quantity of student writing since her students became Internet publishers. "Kids know parents or teachers are going to say, 'Good job,'" she explains. "When a stranger sends email commenting on their work, it means a lot to my students."

Not only does technology help students extend themselves outside classroom walls, it helps adults connect with classrooms to help kids. People who otherwise wouldn't have time to serve as mentors to kids find that they can correspond with students by email. And working parents, whose schedules can make conferring with their children's teachers a logistical challenge, can connect more readily through email or by direct phone connections to classrooms.

"The kids are learning better. I'm constantly reassured every time I put them on the computers. They're so excited, and they get so much done. Their attitude toward the entire class changes."
—Bart Hays, teacher, Morse High School, San Diego

But advocates say that new technologies can be used to do more than make school fun or help busy parents reach teachers. As they see it, teachers can use Internet-based explorations as part of an entirely new approach to education that is more appropriate to the world students will face as adults.

Traditional classrooms—with their strong central authority, carefully prescribed curriculums, 55-minute classes, homogeneous student groupings, and emphasis on rote learning—may have trained children adequately for the old-style mass-production economy, analysts say. That was a world in which products changed relatively infrequently, work typically was organized according to a strict division of labor controlled by steep hierarchies, and individuals were expected only to master relatively discrete and simple tasks that they performed repeatedly. Often, they held such jobs for years.

In the Information Age economy, however, businesses must innovate and customize their products constantly. Because hierarchical workplaces can't adapt to changing market conditions rapidly enough to survive, authority has increasingly devolved to self-directed, inter-

disciplinary teams. Frequent job changes have become much more common. This environment places a premium on workers who are flexible, innovative, self-directed, and able to solve problems collaboratively.

In his 1991 book, *Work of Nations*, former Labor Secretary Robert Reich wrote that most schools are failing to teach the creativity, problem-solving, and lifelong-learning skills required in the new economy. In the typical classroom, he argues, "reality has been simplified" into prepackaged lesson plans, lectures, and textbooks, leaving students little occasion to find meaning for themselves. For instance, he says, "the tour through history or geography or science typically has a fixed route, beginning at the start of the textbook or the series of lectures and ending at its conclusion. Students have almost no opportunity to explore the terrain for themselves."

"Certainly it is a much more expensive and slower process than anyone anticipated."
—Beverly Hunter, program manager for educational technology systems, BBN Corp.

The same year that Reich wrote those words, a report by the Labor Secretary's Commission on Achieving Necessary Skills suggested that workers in the future must be able, among other things, to "work on teams, teach others, serve customers, lead, negotiate, and work well with people from diverse backgrounds." The SCANS report, as it was known, also said that the workplace of the future would require the ability to "acquire, organize, interpret, and evaluate information and use computers to process it."

Of course, education involves more than teaching children how to survive in a changing job market. Equally important, say educators, is helping students develop means of making sense of today's information-rich environment. Knowledge is changing so rapidly that teaching an established body of facts is of little value. Instead, schools must give students the skills to make sense of what Reich calls "the chaos of data that already are swirling around us."

"In 1850 it took about 50 years to double the world's knowledge base," notes Frank Withrow, former director of learning technologies for the Council of Chief State School Officers. "Today, it takes only a little more than a year. The way we store, retrieve, and use information is vastly different in the Information Age." Modern society, Withrow said, "does not need 'knowers,' it needs 'learners.'"

Barriers to success

So far, however, this vision remains largely unrealized outside a small handful of schools. Even the staunchest advocates of computer networking in education concede that in most places technical problems, inadequate training, and insufficient time for teachers to figure out ways to integrate technology with the curriculum have combined to thwart the dreams of reformers for a technology-driven overhaul of the education system.

"Certainly," says Beverly Hunter, program manager for educational technology systems at BBN Corp., and a veteran in the education-technology field, "it is a much more expensive and slower process than anyone anticipated."

There are a number of reasons progress has come more slowly than innovators like Hunter expected. For one thing, the technical

challenges have proven daunting, as anyone who has lived through the installation of a computer network in the workplace can testify. Businesses generally assume that computer networks require one technology specialist for every 60 users. By that standard, schools would need the equivalent of one specialist for every two classes. But few schools employ any computer technicians at all, even though schools are less able than most businesses to withstand the disruption that system failures and other startup problems can cause.

"If a teacher has planned a science curriculum using technology and the system crashes, she doesn't have time to figure out what's wrong—particularly when she has 30 kids bouncing off the wall," notes Tom Carroll, director of the Technology Innovation Challenge Grants Program at the U.S. Department of Education. "The system only needs to crash a few times before the teacher isn't willing to spend any more time on it."

Cultural attitudes pose even bigger obstacles. The push to connect classrooms draws much of its strength from a belief that students learn best by taking on meaningful, authentic tasks and discovering the truth for themselves. In the reform model, the National Academy of Sciences says, teachers "change from being the repository of all knowledge to being mentors who help students navigate through the information made available by technology and interactive communication. They help students gather and organize information, judge its value, and decide how to present it to others."

Appealing as this approach may sound, it runs against deep-rooted beliefs—including notions that "teaching is telling, learning is listening, [and] knowledge is subject matter taught by teachers and books," Stanford University historian Larry Cuban has noted. It also defies powerful practical considerations—namely, that a relatively small number of teachers have to maintain control of large classrooms of children who come from diverse backgrounds, he says.

In an influential 1993 article, Cuban predicted that efforts to introduce computers into schools would fall short of reformers' hopes, just as experiences with motion pictures, radio, and television had disappointed earlier generations of technology enthusiasts. After an initial gush of enthusiasm, these earlier technologies all ended up being used far less than proponents had envisioned, and the traditional structure of schools remained largely unchanged: knowledge continued to be seen as consisting largely of concrete subject matter that can be broken into discrete segments and conveyed piecemeal from teachers to students.

There are ample signs the pattern is indeed being repeated. In many schools computers sit idle much of the time or are used for passive, rote learning through drill-and-practice routines rather than being used to cultivate higher-order thinking skills like synthesis, analysis, and communication. And in many cases teachers and students don't seem to know how to take advantage of their newly obtained network connections. "Thousands of schools are getting wired, and all the students are doing is surfing the web," says Roy Pea, director of the Center for Technology in Learning at SRI International Inc., in Menlo Park, California. "There are very few educational activities." Pea worries that members of the public will grow disenchanted. "I'm worried about NetDay hangover," he says.

Aimless surfing and a preoccupation with what's "cool" have led some to conclude that education-by-Internet is more glitter than

substance. In an April 1997 letter to the *Wall Street Journal*, Bruce R. Buxton, headmaster of the Falmouth Academy in Massachusetts, called the drive to wire the nation's classrooms a "national policy disaster." The *Journal* had described a project in which eighth-graders in Bayonne, New Jersey, pulled down National Aeronautics and Space Administration (NASA) satellite images showing the path of the Gulf

"At the first national conference we held, everybody wanted to know about funding and hardware. Now, many of the questions focus on curriculum, educational policies, and equitable use policies."
—Connie Stout, director, Texas Education Network

Stream. Such "seemingly harmless but gaudy" exercises, said Buxton, represent "Disney education: clean, wholesome, and passive."

Critics also argue that technology enthusiasts have their pedagogical priorities all wrong. All too many network-based teaching projects, the critics say, confuse access to information with real knowledge, and mistakenly elevate the capacity to compile data above the ability to analyze and understand it.

"Isolated facts don't make an education," wrote Clifford Stoll in *Silicon Snake Oil*, his 1995 critique of cyber culture. "Meaning doesn't come from data alone. Creative problem-solving depends on context, interrelationships, and experience. . . . And only human beings can teach the connections between things."

Theodore Roszak, who decried the growing use of computers in school in his 1986 book, *The Cult of Information*, agrees. "The idea that children need more and more information is wrong," said Roszak in an interview. "Children need a graceful way of dealing with whole ideas. They need to know how to talk about them, write about them, and make critical judgments about them. That's what they find in books and other people's minds. It has nothing to do with points of fact."

Technology and school reform

Perhaps surprisingly, teachers who have been working with technology for some time say that critics like Roszak have a point. They, too, say that by itself technology won't improve student learning. But they say that it can be a very useful tool if accompanied by other school reforms.

Back in 1986, Larry Cuban was chiding computer advocates for failing to consider social constraints on schools. "Unless existing classroom and school settings are altered substantially, much beyond the conventional will be tough to attain," he wrote in his book, *Teachers and Machines: The Classroom Use of Technology Since 1920*. "No computer advocates that I have read or heard, for example, have suggested that schools should hire more teachers and adults to reduce the teaching load, bringing it closer to the college [staffing level] than to the factory. No computer advocate urges increasing school district budgets by half to modify the existing school and classroom arrangements concerning class size, governance, training, and teacher collaboration. Their sole recommendation is to put money into classroom computers."

But now, a growing number of computer advocates are addressing the kind of broad education reform issues that Cuban said they were neglecting 11 years ago. "At the first national conference

we held, everybody wanted to know about funding and hardware," recalls Connie Stout, director of the Texas Education Network. "Now, many of the questions focus on curriculum, educational policies, and equitable use policies."

Many teachers say that they need more time to prepare lesson plans and work collaboratively. Others stress the need for smaller class sizes—not because technology requires it, but because small classes are a prerequisite for quality education, with or without computers. "The ideas advanced in the literature converge on a central notion—that small, nurturing, personal schools, in which educational activity can be tailored carefully to individual students' needs and interests, are most effective and most compelling," say Joshua Reibel and Jennifer Hogan of the Institute for Learning Technologies at Columbia University.

Some technology advocates also have started to re-emphasize education fundamentals. "The big problem I see is literacy—not computer literacy, but the simple ability to read and write," says Ferdi Serim, a teacher at John Witherspoon Middle School in Princeton, New Jersey, and author of *NetLearning: Why Teachers Use the Internet*. "If you put the Internet in the hands of somebody who can neither read, write, nor think well, you aren't giving them much," continues Serim, who says that some of the kids who come into his computer lab only know how to use the Internet to connect with the MTV website. "But for kids who are equipped with language and learning skills, it's like a rocket."

More broadly, technology advocates have begun to put more emphasis on finding ways to integrate networking tools with the school curriculum. In the past few years the number of lesson plans circulated on education websites and email lists has grown enormously. And education think tanks are devoting increased attention to defining the higher-order skills associated with reformers' ideas about computer networking in schools, and working to develop better tools for assessing students' progress in acquiring them. "We have been looking at computers so much that we haven't been thinking enough about what happens away from the computer. But that's where learning takes place," says Serim.

All these trends reflect a growing awareness that technology is not an end in itself, and that any successful use of technology must begin with clearly defined educational objectives. Thus in Baltimore, Maryland, the Abell Foundation has stopped providing funds for schools simply to install computers. "If they just want computer labs, we say, 'No,'" says Kate Walsh, program officer for education. "But if they have a good program that could make good use of technology, we will support them. Technology doesn't drive a program, it's a tool."

Such views may represent a less grandiose vision for what computer networking can accomplish than many people held a few years ago. But advocates believe that a more balanced understanding of what technology can—and can't—do will help focus the public on the need to address issues that are more fundamental. At the same time, it could reduce the danger of public disillusionment and backlash against technology.

"This a very high-stakes game," says Serim. "We don't serve anybody by building up expectations beyond what can be delivered."

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An education technology agenda

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An education technology agenda

The Internet as a teaching tool is a work in progress—one that is being produced not by individuals but by communities of learners, many of whom have come together through the new communications channels opened by technology. Its educational value ultimately will depend on what we put into it and what we do with the information we take out of it.

"In the Information Age," says education consultant Margaret Riel, "factual knowledge is plentiful. What is scarce is the intellectual work of giving value to information, of transforming information into useful knowledge systems. This is the work of communities."

For many, that work begins with creating educational content worthy of the powerful new transmission pipelines technology creates.

Creating better content

Writer Theodore Roszak once searched the World Wide Web for information about Beethoven. Using one of the popular search engines, he quickly found thousands of websites carrying the famous composer's name. The first was for "Beethoven's Bathroom," a joke shop in New Jersey. Then there were scores of sites related to a popular movie about a dog. When Roszak finally found a site about Ludwig van Beethoven, it was created by an enthusiast with no evident academic credentials. Altogether, Roszak found thousands of supposedly relevant websites, but "almost all of them were useless," he says.

"Of course, there's valuable material there," says Roszak, who once watched kids in a classroom search for information about Aztec culture only to turn up websites on everything from soccer teams and software firms to bowling alleys. "But there's also an awful lot of junk, advertising, and trivia. And there's no quality control."

Roszak's complaint is a common one. Even advocates of using the Internet in the classroom agree that the enormous network, which President Clinton called in his second inaugural address "a commonplace encyclopedia for millions of schoolchildren," is actually an unwieldy, uneven, and often unreliable information source.

"With some exceptions . . . the Internet offers information that is popular, trendy, fashionable, and cool," says Jamieson McKenzie, director of technology and library/media services for the Bellingham public schools in Washington state. "Search for something as central to our national experience as Thanksgiving and you are unlikely to find much more than recipes and tourist attractions."

In his online magazine, *From Now On*, McKenzie analyzed what famous names produce the most "hits" on the HotBot search engine. While God came in first, Bill Gates outscored Thomas Jefferson, Martin Luther King, Buddha, and Socrates. Elvis Presley beat Woodrow Wilson, Jimmy Carter, and Nelson Mandela. "The amount of attention devoted to a particular individual," McKenzie concluded, "seems more a function of their celebrity than their importance to society, their contributions to knowledge, or their good works. The coverage of an idea, a topic, or an issue seems to be shaped more by fashion and fad than significance."

For critics like Roszak, the morass of irrelevant or untrustworthy information shows why the Internet isn't ready for the classroom. And with the rapid growth—and growing commercialization—of the vast network, the deficiencies are getting worse rather than better, they argue. "In the four years since the [Clinton] administration began thinking big about the Internet, cyberspace has become a considerably more cynical, crass, and commercial place," wrote *The New Republic*'s Brian Hecht.

Still, in the past few years there have been substantial efforts aimed at making the Internet a more teacher- and student-friendly place. Resource lists and lesson plans have sprung from a variety of sources. Some of the best are publicly funded; for instance, the Northwest Regional Educational Laboratory, a regional education facility financed by the U.S. Department of Education, offers "Library in the Sky." Universities and colleges have made substantial contributions as well; consider The Faces of Science, an extensive set of profiles of notable African American scientists and engineers compiled by Louisiana State University Libraries.

Some K–12 school libraries also have become useful Internet sources; Chico High School Library in Chico, California, to cite just one, has compiled extensive lists of sources. Nonprofit groups are getting into the act, too. The Committee for the National Institute for the Environment, for example, has begun building a national library of scientifically sound information about the environment; it includes reports by the Congressional Research Service that have long been available to members of Congress but not to the general public.

"In the Information Age factual knowledge is plentiful. What is scarce is the intellectual work of giving value to information, of transforming information into useful knowledge systems. This is the work of communities."
—Margaret Riel, education consultant

Some businesses are starting to offer services that help separate the online wheat from the chaff. Scholastic, Inc., one of the nation's biggest educational content providers and publishers, has developed the Scholastic Network, a web-based resource center for educators. The company also has invested $75 million to develop K–6 social studies and language arts courses. Every unit has an accompanying CD-ROM and uses web sources. McKenzie singles out for praise the Electric Library, which is produced by Infonautics, Inc., in Wayne, Pennsylvania. It weeds out unreliable and irrelevant information sources and provides users access to materials that were all produced by well-known and reputable publishers. Moreover, it comes with a "natural language" search system that doesn't require users to

understand the arcane rules of "Boolean" logic. The cost is fairly modest: one hookup at an elementary school costs $750 a year, while a high school that wants enough capacity to accommodate 35 concurrent users would pay $2,900. But Infonautics admits to some disappointment with the slow growth of its subscriber base, which totaled just 10,500 in the fourth quarter of 1996. "As with many other companies offering products and services via the Internet, we are finding that subscription revenues from consumers are not developing as rapidly as we had hoped," says Marvin I. Weinberger, Infonautics' chairman and chief executive officer.

"It is not a giant encyclopedia, but I think that by teaching the students how to evaluate information we are teaching them a skill that they will use throughout their lives."
—*Kathleen Schrock, Dennis-Yarmouth Regional School District, Massachusetts*

If a stronger market doesn't develop, schools may have to continue relying on the work of individuals for whom taming the Internet to meet the needs of education is largely a labor of love. Kathleen Schrock, department head for technology at the Dennis-Yarmouth Regional School District in South Yarmouth, Massachusetts, shows that one individual can add substantially to the efficiency and value of online searches by selecting and organizing useful references. Schrock, who started keeping track of useful Gopher sites on index cards in 1993, now carries links to more than 1,200 sites of interest to educators, as well as some original content, on her highly regarded web pages.

"I can usually find something about anything that a student asks for," says Schrock. But she describes the information as "value added" to print collections, not a substitute. And although she and a number of other school librarians have been developing criteria for students and teachers to use in evaluating websites for reliability, she says she still requires students to seek a print source, whenever possible, to verify information they obtain on the Internet.

"Depending on the subject, the Internet is a great place to start to find out both sides of an issue, introductory and detailed information, and those hard-to-find topics," Schrock says. "It is not a giant encyclopedia, but I think that by teaching the students how to evaluate information we are teaching them a skill that they will use throughout their lives."

Forging a new curriculum

Evaluating information is one of the higher-order skills that students must learn in the Information Age, according to teachers at the John Witherspoon Middle School, in Princeton, New Jersey. It is preceded by "gathering" and followed by "analyzing" and "presenting." Collectively, acquiring these skills adds up to learning how to think, the teachers say.

The Bellingham public schools have articulated even more higher-order skills. For instance, teachers there have broken down the research cycle into seven stages: questioning, planning, gathering, sorting and sifting, synthesizing, evaluating, and reporting. The schools have developed staff training modules for each skill, as well as "rubrics" for evaluating student performance on them.

McKenzie, the technology coordinator, puts special emphasis on the first stage. In questioning, the student clarifies what new insight is required, what he or she already knows, and what data and insight

are required to shed light on the question. "Questioning is the primary technology to make meaning," he says. "Questioning converts data into information, and information into insight."

And how does a school know if it has succeeded in teaching students the various higher-order skills? The Oak Harbor School District, in Washington state, has developed a set of rubrics for measuring student progress on the various skills of the research cycle. A student would score a "5" in questioning, for instance, if she "discovers independently an issue or problem which needs a decision or solution," while she would get only a "1" if she "relies upon adults to state questions and topics." Similarly, a researcher would get a "5" for planning if he "selects high-quality sources independently and efficiently," but would be given a "1" if he "wanders from source to source without questioning which source will be most helpful." And coming up with an original decision or solution would merit a "5" in synthesizing, while simply restating the decisions and solutions of others would earn only a "1."

For teachers unsure how to apply these concepts, a growing number of lesson plans are available online. Often, the lessons involve collaboration and interdisciplinary study. In a "web quest" called Searching for China, for instance, students join teams whose mission is to make sense of China. Each must choose to play the role of foreign investor, human-rights worker, museum curator, state senator, or religious leader. Each then must read a dossier tailor-made for the role he or she chooses. After studying the materials, the interdisciplinary teams come together to "discuss, persuade, argue, deal, and brainstorm" a team action plan.

"We know the answers are not easy," the quest designers say. "That's why they are real! Attention: You are not 'playing school.' The future could depend on you and your ability to understand and communicate."

Lesson plans may be helpful to students and teachers, but it's even more valuable for students to devise lesson plans for themselves. All the higher-order skills come into play—defining the question, gathering resources, sifting and sorting them, and figuring out how to present them in a way that is meaningful to somebody else. And the result is something of genuine value: high-quality student work helps fill the need for well-vetted content in the online world.

Mary O'Haver, a fifth-grade teacher at Fairland Elementary School in Montgomery County, Maryland, has made producing educational materials for other schools a major part of her curriculum. "From the beginning, our web space has been a place where we produce resources, not promote ourselves or our school," says O'Haver. "The emphasis has always been, and continues to be, about what value we are *adding* to the Internet." O'Haver's website has almost 200 student projects, most of which include documentation on how they were done. "I get email thanking me for projects students put up two years ago that other students are finding helpful in their own class work today," she says.

O'Haver says her students are impressed when they see commercial websites and realize people get paid for producing them. The fact that they, too, can produce something of real value—something that may be used by people far beyond the school's own walls—is a powerful motivator.

And the discipline that O'Haver forces on her students to take responsibility for their work can be a powerful lesson. She requires her students to use multiple sources when researching a project, including notes from four textbooks, two CD-ROMs, several books other than textbooks, and at least one website. "This [approach] helps students evaluate what they find on the Internet," she says.

Once, O'Haver says, her students were indignant when they found that textbooks said Ponce de Leon was born on one date while a website they found gave a different date. "If they're going to put it on the Internet, they should check their facts!" said one girl. In their own report, the children indicated there was conflicting information about de Leon's exact birthdate. "Now the kids are looking for mistakes," says O'Haver. "This has instilled in them a sense of pride in being sure that the information they put on the web does not have mistakes."

Because much of the educational material on the Internet is aimed at adults, O'Haver's students often repackage it for kids using larger fonts, simpler words, or more pictures. But some of the student work now available online is as sophisticated as any professional product. Students at Winston Churchill High School in Potomac, Maryland, created Economics and Investment: A Stock Market Simulation, an award-winning primer on the stock market, complete with company profiles, a tutorial, and time-delayed market results that enable users to see how hypothetical investments would have performed in real life.

Developing new assessment tools

As the nation's investment in computer networking grows, measuring its educational impact has become increasingly important. "How do you assess whether this stuff actually does anything?" asks Ricardo Tostado, a policy analyst for the Illinois State Board of Education. "We need to see what this is accomplishing."

Numerous studies have failed to provide conclusive answers, and opinions on the issue vary widely. Nora Sabelli, a senior program officer at the National Science Foundation, believes there are tangible signs—namely, higher test scores—that computer networking is effective. "We know how long it takes to get test scores up, and why," she says.

But others aren't so sure. "We have yet to find evidence that the introduction of new technology in schools raises test scores," says the Abell Foundation's Kate Walsh. Even some advocates, like consultant Margaret Riel, concede that test scores don't prove the case for computer networking. "In general, people are not finding test-score differences," she says. "There is some disappointment in that."

The difference in interpretations stems in part from a methodological problem: it is very difficult to isolate the impact of technology from other changes, such as new teaching styles, that also affect student performance. In a seminal 1985 study Richard Clark, an education professor at the University of California Los Angeles, reviewed earlier studies that suggested computers improved student performance. Much of the supposed beneficial impact disappeared, he said, when the teacher or instructional method was held constant.

Clark also reported that short-term studies generally credited computers with having a bigger effect than studies tracking student performance over longer periods. This has led some analysts to con-

clude that much of the gain associated with computers may have resulted from the novelty of the new technology, rather than some underlying advantage.

"Educational media alone do not influence the achievement of students," say authors Ann D. Thompson, Michael R. Simonson, and Constance P. Hargrave in the Association for Educational Communications and Technology's exhaustive *Educational Technology: A Review of the Research*. "Media permit the delivery and storage of instructional messages but do not determine learning."

Reliance on standardized tests is another problem. While they can measure student mastery of discrete skills and factual knowledge, many analysts believe they don't adequately gauge whether students are acquiring higher-order skills such as the ability to solve complex problems, think analytically, synthesize information from diverse sources, and communicate effectively.

Riel pioneered some alternative assessment tools in the late 1980s and early 1990s. In one study she found that fourth-graders in California, Hawaii, Mexico, and Alaska who participated in an online news service called Computer Chronicles showed marked improvement in reading and writing skills compared with other students. Riel concluded that editing other students' writing is more effective than looking for one's own mistakes, and that students felt more comfortable editing the work of distant peers than that of their classmates.

Another study by Riel suggested that students perform better when they're given authentic tasks rather than make-work assignments. In the study judges were given two sets of papers written by Israeli students—some written for a student network and others for teachers. Without knowing for whom the papers were written, the judges found that writing done for peers used less slang, contained fewer errors, had more complex constructions, and was more substantive and supported more effectively by details.

Probably the most successful alternative tools for tracking a student's progress is "portfolio assessment," in which students demonstrate their achievement with samples of their work. An electronic version is now available: the Committee for Economic Development reports that Scholastic, Inc., has developed a system that teachers can use to scan into a computer samples of students' written work, video

There are no tools for assessing the value of instruction that results in students being more fully engaged in their communities or developing friendships with kids on the other side of the world.

clips, and other information. With more and more students presenting their research findings in multimedia form, this should prove to be a useful new tool.

Still, alternative assessment tools have a long way to go in winning public acceptance. They rely on subjective evaluations more than standardized tests. And like the more complex phenomena they are designed to gauge, they are harder to reduce to simple, quantifiable scores.

Moreover, even portfolio assessment doesn't measure all the possible gains from new teaching techniques. How, for instance, does one gauge whether students are more motivated? According to the Committee for Economic Development, researchers at the University of British Columbia in Vancouver, Canada, found that high

school students who enrolled in experimental physics courses that relied heavily on interactive videodisks, computer simulations, microcomputer-based laboratories, and multimedia activities did no better on tests than other students. But the kids from the experimental program enrolled in advanced physics classes at twice the rate other students did. The committee reported on those findings in *Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education*.

Finally, there are no tools for assessing the value of instruction that results in students being more fully engaged in their communities or developing friendships with kids on the other side of the world. "We are doing everybody a disservice if we focus exclusively on test scores," says the National Science Foundation's Sabelli.

Supporting professional development for teachers

Inadequate teacher training is perhaps the biggest bottleneck limiting effective use of computer networking in many of the nation's classrooms. Although years ago some computer enthusiasts may have imagined that computers would take over many of the tasks of teachers, or that many classroom teachers would see their role subordinated to master teachers in central locations who could reach millions of students using distance-learning tools, it is now widely accepted that technology actually puts more demands than ever on classroom teachers.

There are several reasons for this. Learning the mechanics of using hardware and new software is just one challenge. More difficult yet, teachers say, is developing lesson plans that incorporate the resources available over the Internet into the school curriculum. In addition, teachers accustomed to teacher-centered classrooms have to learn a new set of techniques to manage the transition to student-centered learning. And as individual students seek and find knowledge from an ever-wider array of sources, rather than simply absorbing a uniform body of knowledge, teachers often find that they must be more knowledgeable than ever about their particular subject matter to respond to student questions and help direct their research. "Teachers are nearly unanimous in concluding that, in the early stages of technology implementation, at least, their job becomes harder," concluded Barbara Means one of the authors of the Department of Education-sponsored report, *Using Technology to Support Education Reform*.

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—*Barbara Means, co-author,* Using Technology to Support Education Reform

Despite these findings, most schools cut corners on training. In a 1995 report, *Teachers and Technology: Making the Connection*, the now-closed Office of Technology Assessment suggested that schools should be devoting at least 30 percent of their technology spending to training. But Quality Education Data, the Denver-based research firm, estimated that school districts are devoting only 5 percent of their technology budgets to training in the 1996–97 school year. Moreover, just 13 percent of public schools require teachers to obtain training in advanced telecommunications, according to the National Commission on Educational Statistics, and while some schools offer teachers

incentives to seek training on their own, 51 percent leave the matter entirely up to teachers.

Traditional training methods are unlikely to fill the gap any time soon. The Office of Technology Assessment found that most teacher-training programs at colleges make little use of technology. And it said that the typical approach to in-service teacher training—short courses on specific computer applications or other single topics—may be particularly ineffective in preparing teachers to use computer networking in their classrooms. As most computer users can testify, learning a new software program requires hands-on practice. Continuing support from a good mentor is also important, yet only 6 percent of elementary schools and just 3 percent of secondary schools employed full-time computer coordinators in 1992.

Even when teachers get training in the fundamentals of using computers, they often don't get assistance in figuring out how to use them in their courses. Jamieson McKenzie, the technology director for the Bellingham public schools, recalls visiting one school that had separate computer labs for the sciences, social studies, and English—and faculty who were better trained than their peers at most schools. But even though the business education teachers all knew how to use spreadsheets, he says, "when I asked them how they would use spreadsheets in class, no one had any idea."

While traditional training could help teachers make better use of technology, veterans of the education technology movement say teachers can learn better—and at lower cost—from each other. Many successful schools incorporate technology discussions into their weekly faculty meetings. Clear View Charter School in Chula Vista, California, for instance, holds technology hours every Friday afternoon. They invariably are well attended. "We share student work, evaluating teaching by the quality of students' work," says principal Ginger Hovenic.

Teachers who go online can find even more help, including a wide range of resources, discussion groups, lesson plans, and other teachers eager to exchange ideas or launch collaborative learning projects. Once a teacher knows enough to tap into these resources, training can become easier.

But another problem arises. "The biggest issue teachers constantly raise is the time issue," says Margaret Honey, deputy director of the Center for Children and Technology in New York. "They're tremendously enthused about all the resources [available on the Internet], but finding the ones that are going to be useful to your curriculum can suck up hours of time."

Ultimately, the time problem may be harder for school districts to address than providing basic training, because the solution may involve a substantial, continuing expense. The Department of Education argues in a report entitled *Prisoners of Time* that schools should employ more substitute teachers to give regular classroom teachers more time to prepare lesson plans.

"This isn't specific to technology," says Kristi Rennebohm Franz, a teacher at Sunnyside Elementary in Pullman, Washington. "But it would make an incredible difference if the substitute teachers who replaced us during our release time were always the same people. This would provide consistency to the students, ease the job of the substitute, and provide greater peace of mind to the released teacher."

Ensuring equity

Policies concerning technology in schools have assumed special urgency because uneven access to computer networks may be contributing to the widening income gap between the rich and the poor.

In 1994 the wealthiest 20 percent of Americans accounted for 46 percent of national income, while the poorest 20 percent earned just 4 percent, according to Lawrence Mishel, Jared Bernstein, and John Schmitt of the Economic Policy Institute in Washington, D.C. Wage differentials have increased partly because demand for high-skilled workers is rising more rapidly than demand for low-skilled ones. Harvard economists David Autor and Lawrence Katz, along with Alan Krueger of Princeton, found in a March 1997 analysis that workplaces where computers are used account for as much as half of the relative increase in demand for high-skilled workers since 1970.

To the extent that computer skills are important in today's labor market, middle-class kids have a distinct advantage. In July 1996 Nielsen Media Research reported that households with income of $50,000 or more account for 47 percent of all personal computers, even though they represent just 29 percent of the overall population. Similarly, Nielsen said that such families account for 56 percent of all households with Internet access.

Government programs—especially Title I, which provides funds to schools with disadvantaged students—have eased the imbalance somewhat. In the 1993–94 school year, for instance, schools where 80 percent or more of their students were eligible for Title I had one computer for every 26 students, while schools where just 20 percent of students were eligible for Title I had one computer for every 13 students, according to Quality Education Data. But by the 1995–96 school year the gap had narrowed substantially, with the poorest

Source: QED's *Technology in Public Schools*, 15th ed., 1996, and QED's *Internet Usage Report*, 2nd ed., 1997

schools reporting one computer for every 13 students, and the wealthiest one for every 10 students.

Some analysts, however, worry that the government could use technology funding as an excuse to skirt equally important problems. In a number of states governors are seeking big increases in technology spending even as they propose cuts in overall school aid. The tradeoff could be particularly harmful for poor schools, which tend to be older and in worse condition than rich ones. A 1995 report by the General Accounting Office, for instance, found that 60 percent of schools in central cities, which serve predominantly poor student populations, had insufficient phone lines, electrical wiring, or electrical power to support communications technologies, compared with 47 percent of schools in rural areas and small towns.

"We get reports—not data, but anecdotal evidence—of computers being donated to poor districts, but the computers are antiques, the districts have no funds to train anyone, and the districts don't have networks," says Craig Foster, executive director of the Equity Center, an advocacy group that represents 375 Texas school districts. "People tell us that they have seen rooms in poor schools with stacks and stacks of computers because they have no way to hook them up."

That helps explain why poorer schools are less likely to be connected to the Internet than wealthy ones. The National Center for Education Statistics reports that Internet access is available in just 53 percent of schools where more than 70 percent of students are eligible for the government's free or reduced lunch program, while 78 percent of the schools with less than 11 percent of eligible students are connected.

"However you look at it, you cannot assume that a school that is technology-rich and resource-poor is as good as a school that is technology-rich and resource-rich," American Civil Liberties Union lawyer Chris Hansen told *Education Week* in a March 1996 report examining the issue of technology and equity in schools.

The equity question is far more complex than just a matter of hardware and funding, though. "Children in urban schools and children in suburban schools have a very different sense of self-efficacy when it comes to technology," says Louis M. Gomez, an associate professor of education and computer science at Northwestern University. "What I've come to understand of this problem is that it's about a culture in schools. There are urban schools that have access and still don't use the technology. It is because there is no culture of use."

Gomez says that the use of technology is a function of local culture and a community's "capacity for change," and that we shouldn't expect the same kind of computer use in all schools. But if computer technology really does shape one's prospects for success later in life, different patterns of use would be a matter of grave concern. Some reports in the early 1990s, for instance, suggested that students in wealthier schools are more likely to use computers to develop higher-order skills, while kids in poorer districts use them more frequently for repetitious drill-and-practice routines. "Economically disadvantaged students, who often use the computer for remediation and basic skills, learn to do what the computer tells them, while more affluent students, who use it to learn programming and tool applications, learn to tell the computer what to do," wrote Delia Neuman, associate

professor at the University of Maryland College of Library and Information Services.

Unless disadvantaged students are introduced to more challenging uses of computers, they may be consigned to a new technological underclass, warned Charles Piller in a widely cited 1992 report published by the magazine *Macworld*. "Those who cannot claim computers as their own tool for exploring the world never grasp the power of technology," he said. "Such students become passive consumers of electronic information. . . . Once out of school, they are relegated to low-wage jobs where they may operate electronic cash registers or bar-code readers. They may catch on as data-entry clerks, typing page after page in deadly monotony. They are controlled by technology as adults—just as drill-and-practice routines controlled them as students."

There has been little additional research on this issue since Neuman and Piller published their findings. It's possible the situation has changed. Considering the potential ramifications, it should be a high priority for future research. Says Neuman: "It's clear we aren't giving this issue attention commensurate with its importance."

three

What's going on
Effort to deliver computer
networking to schools

3

What's going on: Efforts to deliver computer networking to schools

The United States has made significant strides toward achieving President Clinton's objective of connecting every classroom to the Internet by 2000. Between 1994 and 1996 the portion of the nation's schools that were connected almost doubled, to 65 percent. The National Center on Education Statistics, which compiled those figures, said that all but 5 percent of schools expect to be online in the next few years. The much bigger task—of connecting individual classrooms as well as central offices—is going more slowly. In 1996 just 14 percent of classrooms were wired for Internet connections. Still, that was more than quadruple the number just two years earlier.

As the deadline for establishing network links draws closer, many participants in the education technology effort are starting to emphasize concerns that go beyond installing hardware and network connections. Can we sustain a vision of Information Age education even after the infrastructure is in place? And what can we do to ensure that the effort to link schools produces a sustained improvement in the quality of education provided to our children?

From Washington, D.C., to communities all over the country, many people are wrestling with these questions.

The federal government

President Clinton has promoted computer networking aggressively since he was first elected in 1992. To "bring the power of the Information Age into all of our schools," he says, "will require connecting every classroom and library to the Internet by the year 2000; making sure that every child has access to modern, multimedia computers; giving teachers the training they need to be as comfortable with the computer as they are with the chalkboard; and increasing the availability of high-quality educational content."

The federal government took a big stride toward helping schools sustain the networking effort on May 7, 1997, when the Federal Communications Commission (FCC) approved a plan that will make schools and libraries eligible for basic and advanced telecommunications services at discount rates.

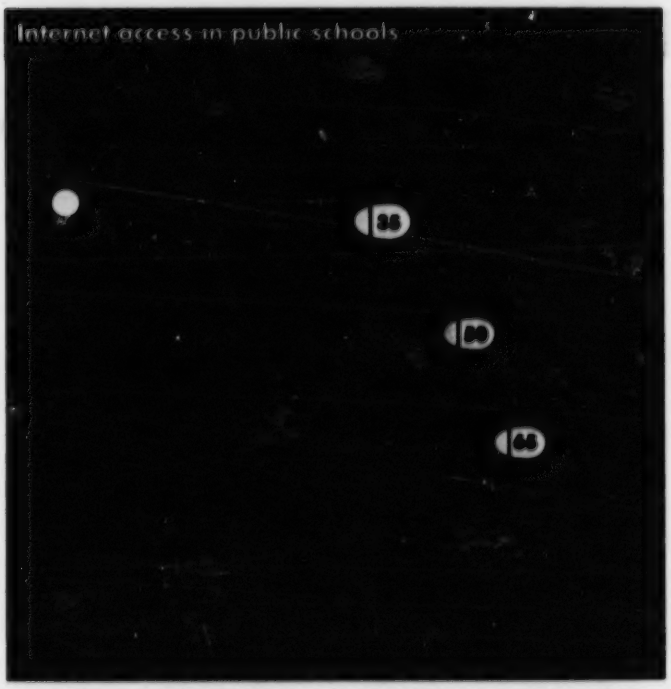
The discounts, which will apply to all commercially available telecommunications services, Internet access, and internal connections, will range from 20 to 90 percent. Schools serving larger portions of children from poor households will qualify for larger discounts. The discounts will also be weighted in favor of rural schools. The FCC set

a $2.25 billion annual cap on the rate subsidies, which are scheduled to take effect in 1998.

Public interest advocates viewed the FCC action, which was required under the Telecommunications Act of 1996, as a watershed event. "Schools are important stepping stones to a truly networked community, and society as a whole needs to take responsibility for keeping them connected," said Andrew Blau, director of the Benton Foundation's Communications Policy Program. "The commitment to schools becomes a benchmark for a broader social commitment to equity, access, and realizing the social benefits of this technology."

The discounts won't cover the entire cost of maintaining school Internet connections, though. In a 1995 report prepared for the U.S. Advisory Council on the National Information Infrastructure (NIIAC), McKinsey & Co. estimated that the full cost of maintaining network links would range from $4 billion to almost $14 billion a year, depending on whether schools seek connections just for computer labs or for every classroom. But schools will have other ways to reduce their costs. For one thing, they may persuade state regulators to require that they receive the same discounts on intrastate rates as the FCC has ordered on interstate rates. Just as significantly, the FCC has urged schools to join other organizations in creating buying consortiums so that they can qualify for volume discounts on their telecommunications services. That would reduce the base rates from which the FCC-ordered "universal service" discounts would be calculated.

Vice President Al Gore called the FCC's decision the "cornerstone" of the Clinton administration's push to connect every U.S. classroom and library to the Internet by 2000. "We now can go from a world where most teachers don't even have phones to a world where all teachers can help their students talk to the world," he said.



Source: U.S. Department of Education, National Center for Education Statistics, "Survey on Advanced Telecommunications in U.S. Public Schools, Fall 1996."

Because the federal government lacks the resources to accomplish this on its own, however, the Clinton administration has encouraged schools to find partners to help networking efforts. The Technology Literacy Challenge Fund, which provides grants for school technology programs, requires states to develop technology plans that provide for collaboration with outside partners. It also says that states must address how to facilitate access by poorer schools to advanced telecommunications. The administration will announce the first $200 million in grants in September 1997, and is seeking $245 million more for the fiscal year beginning October 1, 1997. President Clinton has said that he would like Congress to appropriate a total of $2 billion over the next five years. Similarly, the separate Technology Innovation Challenge Grant program seeks to encourage the formation of consortiums—consisting of local school districts, museums, software designers, universities, libraries, and state agencies, for instance—to encourage innovative teaching techniques that integrate technology with the school system. Each grant runs for five years and pays from $250,000 to $1.5 million a year.

The administration is also trying to move away from an exclusive focus on technology toward emphasizing the broader context in which the new teaching tools are used, according to Tom Carroll, director of the Technology Innovation Challenge Grant program. "We still see people coming to us asking just for the technology because they don't have any," he notes. "Then there are groups who have the equipment, and want money to figure out what to do with it. And then there is a third group who begin with an educational need, such as 'Here's how we would use technology to improve reading.' This is the group that gets funded."

Finally, the Clinton administration is working to expand the government's role as a provider of educational resources. On April 18, 1997, President Clinton ordered federal agencies to review their information resources and take steps to package them in ways that will be useful to students, teachers, and parents.

Some federal agencies already have become valued educational resources. NASA allows students to interact with astronauts and gather information about space. The Department of Education supports the Educational Resource Information Center (ERIC), whose AskERIC program maintains a library of more than 900 lesson plans and uses a nationwide network of experts and databases to answer questions posed by educators. Vice President Gore's Global Learning and Observation for a Better Environment (GLOBE) project enlists students in collecting environmental data and using the Internet to share, analyze, and discuss it with scientists and other students. And the Lawrence Berkeley Laboratory, with support from several federal agencies, has developed a program that allows high school students to obtain information collected from professional telescopes.

"People expected to have to redo phone lines, but no one realized that many of these schools need to have all their electric wiring redone."
—*Connie Stout, director, Texas Education Network*

The states

States are grappling with a wide range of issues involving education technology, but they lack sufficient resources to do the whole job.

Texas, for instance, has made a substantial commitment to promote networking in schools. Two years ago, it established a flat, $260 monthly rate for schools to obtain Internet access over high-speed T-1 lines. In addition, it has established a $150 million Telecommunications Infrastructure Fund to help pay for connections and school remodeling needed to support advanced communications services.

While nobody can estimate the actual need for infrastructure building, it is generally agreed that $150 million falls far short of what the state's 7,000 elementary and secondary schools need. "School buildings in Texas are, in general, old," says Texas Education Network Director Connie Stout. "People expected to have to redo

Texas provides schools with $30 per student per year for technology. But the state would have to provide at least $100 to $150 per student to ensure that poorer schools keep up with wealthier ones, says Craig Foster, director of the Equity Center in Austin.

phone lines, but no one realized that many of these schools need to have all their electric wiring redone."

Inequities in school funding exacerbate the problem for poorer schools. Texas provides schools with $30 per student per year for technology. The "technology allotments" can be used for professional development or acquisition of hardware and software. But wealthier districts are spending as much as six times that amount, says Craig Foster, director of the Equity Center in Austin. Foster says that the state would have to provide at least $100 to $150 per student to ensure that poorer schools keep up with wealthier ones.

Teacher training is also a big concern in the states. Many officials believe that traditional methods aren't working. "Schools' efforts to integrate information technology in recent years have been less than effective due to inadequate planning for professional development, as well as limited access to information technology for teachers and students," the state of Vermont says in its technology plan. "Both pre-service preparation of teachers and in-service activities have not provided consistent opportunities to learn to use information technology in general and in curriculum areas."

States haven't found any silver bullet to solve the training problem, but they are investing substantially in search of answers. Illinois, for instance, maintains seven regional learning technology hubs. Each hub has full-time staff who provide technical assistance and training, curriculum ideas, technology development plans, and more. As teachers and school officials have become more knowledgeable about technology, the hubs have been able to concentrate on tougher issues such as curriculum development.

"Initially, the hubs were providing a great deal of instruction on the basics of the Internet and technology," says Ricardo Tostado, Illinois Board of Education staffer. "Now, enough teachers and administrators have been trained so that the hubs can let superintendents take over this initial training and focus on more advanced applications of technology."

Along with the federal government, state and local officials are putting increased emphasis on the need for partnerships among different players in the education technology arena. The result has been some creative arrangements. In Clark County, Nevada, for

instance, the public school system has forged an alliance with local community colleges. The colleges organize and administer computer systems for the public schools, and in exchange the schools let the colleges use their classrooms at night.

Similarly, Broward County, Florida, allows cellular telephone companies to build towers at the edge of school football fields in exchange for free wireless access to the Internet.

It isn't always easy to form partnerships, however, especially when they involve public sector institutions and private industry. "Some people have a fit when they see a business logo on a promotional brochure for a program," says Tostado. He argues that many businesses "just want to be associated with a good program so they can appear as good corporate citizens." But experiences with programs such as Whittle Communications' "Channel One," which brought advertiser-supported television news into classrooms, have raised serious concerns about commercialism in schools.

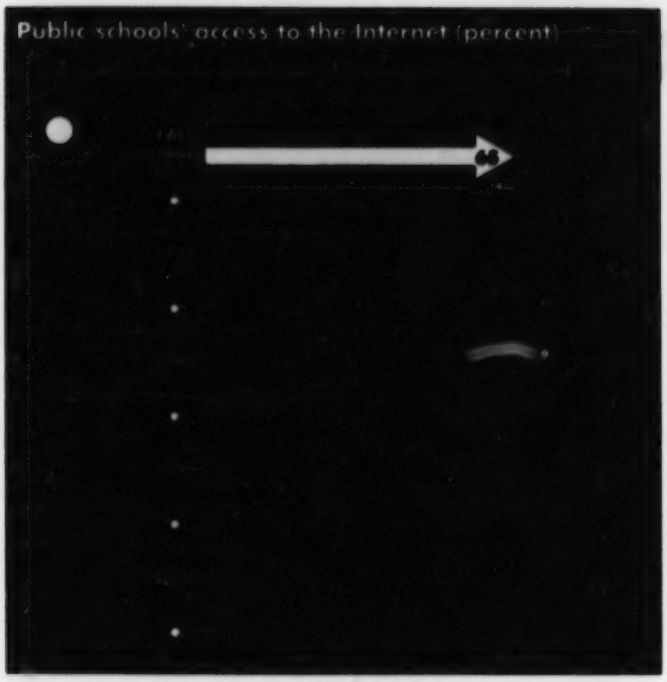
Industry

Telecommunications providers and computer companies are among the most generous contributors to the effort to wire schools for computer-based communications. That isn't surprising. Such giving is a no-lose proposition for them, an opportunity to embrace an issue that is unquestionably popular even as they prime what promises to be a very large new market. Still, a number of companies have demonstrated a commitment to more than just making short-term sales. They may not be totally selfless, but their approach is consistent with the views of many educators who believe that children won't benefit much from new technology if companies simply give away hardware or wires without also providing for support services, teacher training, and community building.

Pacific Telesis is one of the most aggressive corporate promoters of education technology. In 1994 Phil Quigley, the company's chief executive, launched the Education First program. Its goal: to connect 9,000 Californian schools and libraries by 2000. Pacific Telesis promises to provide each library or school with 100 students or more with up to four ISDN lines free of charge for one year; by March 1997 the program had supplied 4,800 lines. The company also gives computers, modems, and multimedia software to the schools and libraries at a special discount. The company's Pacific Bell subsidiary recently announced that it would provide 50 percent discounts on high-speed Internet access services to more than 9,000 schools, colleges, universities, and libraries.

Pacific Telesis also has helped develop curriculums and resources for teachers interested in using the Internet. Pacific Bell has provided funds for three fellowships at San Diego State University's Department of Educational Technology. The fellows are creating Internet and videoconferencing applications, projects, resources, and lesson plans, including the two China "web quests" featured earlier in this report.

IBM also takes a comprehensive approach, encouraging schools to use the technology it provides to fundamentally restructure themselves. The company's Reinventing Education program provides grants to 10 school districts that commit themselves to using technology as part of an effort to achieve systemic reform. IBM provides



Source: U.S. Department of Education, National Center for Education Statistics, "Survey on Advanced Telecommunications in U.S. Public Schools, Fall 1996."

the schools with both hardware and software, guarantees them substantial technical assistance, and trains teachers. In exchange, schools must agree to put up some of their own resources.

In Charlotte, North Carolina, IBM is working with schools to build a computer network over which parents will be able to gain access to their children's homework assignments or communicate with teachers. In Chicago it is supporting the creation of an online collection of science and math resources. In Vermont it is backing the development of software for portfolio assessment of students.

IBM emphasizes the importance of teacher involvement in technology planning. "The goal of these partnerships is not to deliver a simple list of equipment, but instead, to join with educators and help them figure out how technology can solve existing problems or even lead to entirely new approaches to traditional school operations," the company says.

Microsoft says its education projects are designed to help create a "connected learning community"—among other things, by encouraging better communication among parents, students, and teachers with email and the Internet. The company provides free software for communication between parents and schools to any school that buys an NT Server 4.0 package. It provides computers and training to teachers and supports the development of online resources and collaborative projects through Libraries Online! and the Global SchoolNet Foundation.

Few companies have invested more in education technology than AT&T, which has pledged $150 million for the effort. Its Learning Network, created in October 1995, provides 100 schools with five months of free unlimited Internet access via AT&T's World Net service. In addition, the schools receive three months of free voicemail service and two years of wireless phone service on school

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grounds. After the initial free period, the schools receive discounted service. AT&T also plans to offer online mentors to schools.

The second part of the Learning Network is called Learning Points. In this program any AT&T customer can sign up and receive five "learning points" for every dollar they spend on their AT&T phone bill. These points can be donated to the registered school of the donor's choice to be used toward the purchase of computer hardware and software, including many programs and resources offered by Scholastic, Inc.

Other companies are also moving beyond the industry's traditional emphasis on simply providing hardware to schools. Netscape, for instance, encourages development of online resources for schools by sponsoring, among other things, "K-12 World," whose website provides information and links dealing with subjects as varied as virtual libraries, technology planning, and curriculum assistance.

More conventional, though significant, corporate efforts include work by Bell Atlantic to wire the town of Blacksburg, Virginia, or a demonstration project in which Cox Communications of San Diego, California, provides a two-way interactive fiber-optic link allowing videoconferencing between Clear View Elementary School in Chula Vista and San Diego State University.

But analysts say today's students need human capital, more than hardware, from businesses. "Businesses and other organizations in the community have what schools to date largely lack—a concrete set of purposes that would make a difference in people's lives, a set of tasks requiring experienced and skilled individuals for accomplishing them, the human and material resources for getting those tasks accomplished, and a skilled managerial staff for orchestrating that human activity," notes Henry Jay Becker, an education professor at the University of California at Irvine and a leading analyst of the role of technology in schools. "What schools need from businesses and community organizations—more than modest financial donations or contributions of used equipment—is their meaningful activity systems and their managerial talent."

Becker is referring to various mentoring arrangements, school-to-work programs, apprenticeships, and other programs through which businesses can help students draw closer connections between what goes on in the classroom and the "real life" of the workplace. He cites, for instance, the Cocoa High Academy of Aerospace Technology in Florida, a career program in which students at a Florida high school combine class work with experience as apprentices and interns

A number of companies have demonstrated a commitment to more than just making short-term sales. They may not be totally selfless, but their approach is consistent with the views of many educators who believe that children won't benefit much from new technology if companies simply give away hardware or wires without also providing for support services, teacher training, and community building.

in the aerospace industry. The program has eliminated traditional classes. Instead, students work in teams of five. Each team has one computer workstation. Teachers help the teams integrate their academic studies with the real-life experience in the workplace. More conventionally, Hewlett-Packard encourages its employees to participate in mentoring programs using email.

As these examples indicate, schools need everything from hardware to technical assistance to help with teacher training and curriculum. It is difficult for any one company to meet all these needs. But a group of companies have joined an unusually elaborate partnership with nonprofit groups to help students in Washington, D.C. BTG, Inc.,

"What schools need from businesses and community organizations—more than modest financial donations or contributions of used equipment—is their meaningful activity systems and their managerial talent."
—Henry Jay Becker, education professor, University of California

a Vienna, Virginia, information technology company, agreed to donate and install computer equipment at Ballou High School in the District. Bell Atlantic and Potomac Electric Power Company said that they would upgrade the school's electrical circuits and telephone connections. Novell, Inc., an Orem, Utah, company, said that it would provide computer networking software and other teaching and student materials. Novell also offered to let students take its standard exam to be certified as computer network administrators. And both BTG and Electronic Data Systems Corp. pledged to hire graduates who complete the program.

The project, which was organized by former IBM employee Archie Prioleau and backed by a grant from the Commerce Department's Telecommunications and Information Infrastructure Assistance Program (TIIAP), has attracted considerable support. Now, armed with a grant from the Fannie Mae Foundation and other donations, Prioleau's Foundation for Educational Innovation is working with some 40 business, community, and government officials, including Federal Reserve vice chair Alice M. Rivlin, to establish technology training courses and computer networks in other schools and community organizations in the nation's capital.

Prioleau told the *Washington Post* in late May that installing the technology is the easy part of the project. The hard part involves designing courses that will make high school students employable and persuading school officials and teachers to embrace the programs. "If this becomes just a hardware program, we've failed," Prioleau said.

The nonprofit sector

While government and corporate school-technology programs have recently started edging away from a traditional emphasis on hardware, the nonprofit sector has long emphasized issues such as the need for quality educational materials, professional development, and integration of technology with educational programs.

Nonprofits hold a rich store of information that could be useful in classrooms, and new communications technologies are giving them an unprecedented opportunity—and responsibility—to make their research, analyses, and databases available to a new generation of learners. "In an information society," says Robert Loeb, president of the Telecommunications Cooperative Network, "nonprofits produce what everybody wants."

The National Audubon Society, for example, has repackaged much of its information for schools. It recently created "Audubon Adventures," a packet that includes a CD-ROM, books, videos, and a teachers' resource manual. Another CD-ROM available from

Audubon is *Paul Parkranger and the Mystery of the Disappearing Ducks*, which examines issues involving wetlands.

The Franklin Institute, a Philadelphia science museum that emphasizes kids' learning, devotes an entire section of its website to resources teachers can use to enhance their science curriculum. Visitors to the website can learn, for instance, how to teach a course on wind. Critical thinking and inquiry-based methods of learning are emphasized, and a background section includes an online photo gallery, a page of other Internet wind resources, tips for how to introduce a class to the subject, and lists of "windy stories."

The National Museum of American Art in Washington, D.C., offers teaching guides and lesson plans at its website built around the museum's exhibits. And San Francisco's Exploratorium, which specializes in science, art, and human perception, offers kids an online look at one of its most popular demonstrations—the dissection of a cow's eye.

Information can flow both ways, of course. The Virginia Museum of Fine Arts has a section on its website called "You're the Expert." Visitors are asked to pretend that they work at the museum. They then have to make various decisions about exhibitions, such as how to light a sculpture or what name to give a new exhibit. This gives visitors a behind-the-scenes understanding of the museum, and helps the museum get a better sense of what interests people.

Pacific Bell's Education First program helps nonprofit organizations make information that they have collected available to students—and, with the help of students, to the public at large. In a project called Nonprofit Prophets, students investigate community or global problems that concern them and create web pages that explain the extent of the problems, how they started, and what people can do to help. Aimed at ninth and tenth graders, the project helps students connect with adult researchers and experts from around California and with local nonprofit groups. Students have contributed to such projects as the Rainforest Action Network, Sperm Whale Project, and Animal Rights Resource Site.

Because of their strong community ties and history of social services, nonprofits also can serve students in a more active way. A growing number of schools require students to perform community service, and nonprofits are well positioned to organize such real-life learning experiences. The International Education and Resource Network (I*EARN) has helped organize a number of educational projects that enlist students in community service efforts. For instance, students participating in a collaborative investigation of how land clearing and development affect natural water flow have been working with the Global Rivers Environmental Education Network (GREEN) to make some of the research results available to the public. I*EARN also collaborates with the Red Cross on community service projects dealing with disaster relief, HIV/AIDS education and prevention, and environmental awareness.

Nonprofit organizations also have substantial experience with training and professional development. The Washington-based McGuffey Project recently assumed the lead role in organizing the Twenty-first Century Teachers initiative, in which such major education organizations as the National Education Association and the American Federation of Teachers are seeking to encourage more net-

working among teachers. McGuffey is developing a website and plans to arrange opportunities for teachers to share ideas about the use of technology in schools.

In a similar vein, the Rockefeller Foundation has created the Learning Communities Network to improve professional development for teachers. Recognizing that the quality of a student's learning is directly connected to the quality of a teacher's teaching, the two-year old project works with four school districts to develop resources and services aimed at improving teacher training. It maintains a website that serves as a networking opportunity for participants as well as a means of disseminating the resources that are developed. "Our hope is that the strategies developed by each of these sites will become models for other districts," says Marla Ucelli, associate director of Rockefeller's Equal Opportunity division.

Ucelli is also co-chair of Grantmakers in Education (GIE), a group of foundations that support education. GIE has a technology subgroup that, among other things, educates other foundations on technology issues. This group is composed mostly of corporate foundations from the technology industry.

One of these, the David and Lucile Packard Foundation, is supporting efforts to create a National Education Telecommunications and Technology Information and Resource Center, which will help states, regional agencies, and school districts implement the universal service components of the 1996 Telecommunications Act. The center will help match available equipment and services to local needs, negotiate with vendors, integrate new purchases with daily routines, provide related professional development, and interconnect with other learning environments.

"While state and local education agencies are doing much to plan and implement technology and telecommunications at the local level, they report having difficulty finding out about and integrating these new federal resources into the local efforts," says a report put out by Packard. "In the absence of a national program or National Education Telecommunications and Technology Information and Resource Center . . . many education and library agencies will not have the necessary information and support to assist local schools and districts. The result could be that important national programs and initiatives designed to benefit teachers and learners are not implemented and consequently misconstrued by the Congress as unnecessary."

Community technology centers

Another important set of players in the school technology drama demonstrates that teaching kids isn't the responsibility of schools alone. In a number of places community technology centers are helping people in predominantly low-income neighborhoods gain access to the new information networks. In some cases these centers are helping schools introduce children to information technologies. And because they are grassroots organizations, they are serving as models for how schools can excite children, engage adults, and involve entire communities in networking.

In Los Angeles, for example, Break Away Technologies serves a wide range of community members. Each weekday between 9 a.m. and 3 p.m. about 400 elementary school students from the West Angeles Christian Academy come to the center for workshops. Each

afternoon between 75 and 100 teens come to the center for classes or just to surf the Internet. A teen development group, Rites of Passage, also comes in for classes. And on Saturdays, Break Away offers classes for adults.

Joseph Loeb, Break Away's founder, says the center seeks to make students "visible examples of leadership in the community." While computers aren't essential to achieving that goal, they do attract kids, and exposure to technology helps prepare youth for the labor market, according to Loeb. "If someone is computer literate and well mannered, then he or she can go anywhere and be comfortable," says Loeb.

Plugged In, a technology center in East Palo Alto, California, offers 30 different classes ranging from beginning Macintosh to desktop publishing, web page design, and virtual cross-country trips. It operates a for-profit arm, Plugged In Enterprises, that has four main branches: a community drop-in center for people who need help with everything from writing resumes to designing flyers, a design group that creates web pages for local businesses, a division that monitors a teen channel on American Online, and a division that develops multimedia applications and programs. Plugged-In Enterprises is run primarily by teens from the community who are paid from $7.50 to $15 an hour.

Some 200 computer-access centers like Break Away and Plugged In belong to the Community Technology Centers' Network. CTCNet says its member organizations are committed to developing a society in which each member is "equitably empowered by technology skills and usage."

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Schools and their communities

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Schools and their communities

In the end the success or failure of the effort to connect classrooms will be determined in local communities, where most Americans have always believed that control over our schools should reside. Technology advocates are joining others at the local level to encourage numerous diverse stakeholders—including teachers, school administrators, parents, and members of the public—to become more involved in schools.

Teachers

Kathleen Fulton, who directed the Office of Technology Assessment's exhaustive *Teachers and Technology* study, suggested at the conclusion of her research that policymakers should concentrate initially on connecting teachers. Teachers could benefit immediately from any tool that would break down their professional isolation, she said, and in the process would become forceful advocates for spreading technology further.

A number of states accept that logic. Texas, for instance, established the Texas Education Network, or TENET, in 1990, offering every public educator in the state an email account, online academic resources, public data, planned forums, and professional support. Unlike many training programs, the network was launched at the same time as other major educational technology initiatives, not as an afterthought. "We knew we had to prove to educators why they should want to use it," says TENET's director, Connie Stout.

Before the network was started, sponsors held focus groups for teachers, administrators, and secretaries to learn what they wanted a system to do. Initially, the focus wasn't on use of the Internet. Instead the network concentrated on meeting the more immediate needs of its users: when many school staffers said they were interested in job announcements, for instance, TENET set up a jobs announcement section on its website. The consultation process continues to this day, and has grown to include groups other than teachers, such as librarians.

The network has been a big success. Some 50,000 teachers are now registered with TENET. "Teachers report that the peer support is tremendous," says Stout. "They have been so isolated traditionally. We've had teachers say that they would have left the profession by now if this hadn't happened, but they have stayed because they finally have support in the classroom."

Administrators

Many people think the public school system in Bellingham, Washington, went about incorporating technology into its programs in just the right way. First, long before launching an ambitious technology effort, school officials hammered out goals for what they wanted students to master. Later, aware that they lacked manpower to provide all the technical support and troubleshooting that teachers might need, they invested in sophisticated diagnostic software that would enable them to pinpoint network troubles from central locations. They also allowed technology coordinator Jamieson McKenzie to work part time so that he could run a national consulting business, a move that enabled the school system to keep a recognized innovator while staying abreast of the latest ideas and developments in the field of school technology.

The Bellingham administration also went further than most school leaders to address the need for teacher training. It set aside funds that enabled a group of "mentor" teachers to leave their classrooms for a year and work with other teachers on developing ways to use technology in their classes. The pay-off has been substantial: an enthusiastic faculty has given the school district a national reputation by spinning out a growing set of lesson plans for professional development.

The Bellingham schools demonstrate how careful planning by a supportive administration can clear away many of the obstacles that complicate school technology efforts. In the absence of strong leadership by superintendents, school boards, and principals, the task of bringing new technologies into schools can be arduous, as Cynthia Montoya, technology coordinator at Green Valley High School in Henderson, Nevada, learned.

Montoya had to argue for nine months to convince her principal that the library in his brand-new school had archaic technology and that $17,000 would be needed to bring it up to standards. She then had to argue for a year and a half to persuade the school district to bend its policy of limiting schools to one phone line each. Meanwhile, technology projects at Green Valley were repeatedly slowed because they had to be processed through the district's rehabilitation division, which was responsible for retrofitting walls and doors but was not well versed in computer technology.

"My purchase orders would sit on someone's desk for weeks, even though the money was available," Montoya says. "The district staff just didn't understand what was being ordered." Eventually, the district administration agreed to let Montoya and her staff consult on projects involving technology. "I feel like a subcontractor," she notes. "I know more about wiring than I ever thought I'd know."

Montoya also has encountered obstacles getting her ideas past the school district's political leadership. At one point she secured an in-kind contribution from InterAct, a school-focused bulletin board system connected to the Internet. But because InterAct requires schools using its services to adopt rules defining what student uses of the Internet are acceptable, Montoya had to take the issue to her district's school board. There it languished for more than a year. "It's just sitting there because no one on the school board really understands what it's all about," Montoya says. Eventually, Montoya managed to get the school online by establishing for it a T-1 connection in March 1997.

Parents

Most educators agree that parental involvement is a key determinant of children's success in school. Telecommunications technologies are helping a growing number of parents become more involved in their kids' education.

When the Bellingham schools embarked on their effort to wire the district's 18 public schools, officials decided to provide basic telephone service, as well as Internet connections, to every classroom. That added $1.2 million to the $6 million cost, but the payback was immediate—much quicker than for more esoteric pursuits like computer networking. Parents said that the improved access to their children's teachers made it much easier to keep track of homework assignments and other matters. "We got a lot of good feedback from parents," says Jim Stevens, the school district's business and finance director.

New technologies can help parents and teachers overcome the headaches associated with schedules that don't mesh. According to *Electronic School*, a publication of the National School Boards Association, more than 1,000 schools are using a voicemail system developed by Vanderbilt University's Jerold Bauch that can deliver time-delayed messages between parents and teachers. Among other things, teachers say that more students are now finishing their homework because parents are more aware of assignments and classroom activities. Other schools report similar results with email.

Some schools also have used open-house family computer nights to encourage parents to come to schools in person. "Parents see the kids so motivated and skilled," says Kristi Rennebohm Franz, a Pullman, Washington, elementary school teacher. "I've seen turnarounds in a number of parents who had been lukewarm about the use of computers in the classroom."

Clear View, a charter school in Chula Vista, California, keeps its media center open until 9 p.m. so that parents can make use of its fiber-optic connections to the Internet. High school students staff the center during evening hours. Clear View principal Ginger Hovenic says that the step has increased parental involvement in the school.

Morse High School in San Diego has gone even further. It hired a trainer and started a six-week, Saturday-morning computer class for community members. The classes have been so popular that the school plans to add an additional class and is planning for a Spanish-language course in the fall of 1997.

Addressing community expectations

Ricardo Tostado, the Illinois policy analyst, fears that technology advocates could be on a collision course with parents who see technology as an expensive diversion from fundamental reading, writing, and arithmetic. Others say this needn't be the case, though they agree that it's an issue that must be addressed.

Teachers at Sunnyside Elementary School in Washington state say that they incorporated the basics into their technology use from the beginning. And Clear View's Hovenic agrees, saying that her school's technology program teaches the basics—and more. "It no longer satisfies the student to read a chapter in an outdated textbook and answer questions," she says. "By using technology, the children learn the basics of reading, writing, and arithmetic while developing essential work-related skills and positive self-esteem."

The Bellingham public schools, which have been particularly successful in winning public support for their technology efforts, went to great lengths to define their education objectives to include skills that they believe are fundamental, though not exactly what most people mean by the "basics." Bellingham's "essential student learnings," adopted before the school system sought voter approval for a $6 million bond issue to pay for the new technology program, call on the schools to produce students who are "knowledgeable individuals," "quality producers," "effective communicators," "competent thinkers," "effective collaborators," "responsible citizens," and "lifelong learners."

That seems to have satisfied parents in Bellingham, although technology was an easy sell in that city, nestled on a major shipping lane between the United States and Asia and just two hours' drive from Seattle. Things didn't go so smoothly at Belridge Elementary School in McKittrick, California, which often is cited as a object lesson in what can happen when a school fails to heed parental concerns about the fundamentals. Flush with increased tax revenues from local oil development, school officials spent almost $5 million on computer and communications technologies in 1989 and 1990. Each teacher and student had a computer for school use and one for home. Students were using CD-ROMs, laser disk players, video and audio production facilities, multiple Internet servers, and state-of-the-art computer technology. But when test scores two years later indicated no improvement, parents picketed the school. The district subsequently removed the school superintendent and hired a "back-to-the-basics" replacement who pulled the plug on student use of most of the technology.

In retrospect, Steve Wentland, the current superintendent, believes that Belridge tried to go too far, too fast. "Our former superintendent was a great visionary about technology, but the management of the technology wasn't right," he says. "He spent too much money and brought in technology too fast." Wentland is quietly bringing technology back into classrooms, but with a far different emphasis. "Technology is no longer out in the forefront," he says. "The student is. The curriculum is. I don't tell teachers what to do with technology; they tell me what they want to do."

Entire communities

Beyond addressing the concerns of various stakeholders, however, computer networking advocates hope that technology ultimately will draw entire communities together. "We see installing the wires primarily as an opportunity for community building," says Steve Miller, executive director of Massachusetts NetDay. "Schools work best when they are embedded in their communities, when people feel a connection to the education process and educators feel a deep sense of commitment to the community being served. Schools work best when there is constant interaction between the larger world and the classroom so that students have a sense of the real-life relevance of their efforts and teachers can call on the resources around them."

The National School Network, a partnership involving schools, museums, corporations, publishers, and others that was organized by the Educational Technologies Group at BBN Corp. in 1992, lists some of the many ways its members are helping to break down the

barriers between schools and their communities. In Mendocino, California, for instance, students help organize and disseminate information about their community, while students at Cayuga Heights Elementary School in Ithaca, New York, study changing patterns of energy use in their area.

In another project, a team of students from Clarke Middle School in Lexington, Massachusetts, studied the ecology of Spectacle Island in Boston Harbor, which is being reshaped by soil dumped there as a result

"Schools work best when there is constant interaction between the larger world and the classroom so that students have a sense of the real-life relevance of their efforts and teachers can call on the resources around them."
—Steve Miller, executive director, Massachusetts NetDay

of excavation of a third tunnel underneath Boston Harbor. They expressed dismay that the official architectural design plans for the island "do not appear to consider the environmental and financial issues related to the revegetation and maintenance of the island"—for instance, by calling for placement of a sandy beach in a location where sand will be washed away by water currents. "As the taxpayers who will pay for this artificially created maintenance cost, we question the logic of fighting against rather than working with nature," the students said.

What's next?

As these examples demonstrate, something exciting is happening in schools today. The walls between the classroom and the "real world" are starting to come down, and children are beginning to gain unprecedented opportunities to become engaged in meaningful ways with their society. Technology doesn't automatically make such engagement happen, but it does allow for a rich collaboration in education—the building of a true community of learners.

Will this vision become reality for all children, or will it remain the experience of just a few? The answer most likely lies not in our new machines, but in ourselves.

"It is important to remember that technology is a human creation," says Massachusetts NetDay's Miller. "People shape it, like any tool, to serve their own needs and will. We need to learn more about the new technology, decide what we want to use it for and what we don't want to allow to happen. If we want a future that allows us to be full, creative, active, and equal participants, we have to create that future through a process that incorporates those same values. And we need to make sure that we bring our children—all our children—along with us."

five

Resources

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Resources

Overview

Becker, Henry Jay
www.gse.uci.edu/VKiosk/Faculty/hank/ReichSCANSColeman.html
"Business Support for American High School Education: What National Interest Demands, Telecommunications Makes Possible" examines what skills students will need to thrive in the emerging global economy and suggests that telecommunications technologies can help us teach them by forging closer links between schools and employers. Becker, a prominent expert in the field of school uses of technology, focuses in this essay on the views of former Labor Secretary Robert Reich, the 1991 report of the Labor Secretary's Commission on Achieving Necessary Skills (SCANS), and the theories of sociologist James S. Coleman on the connection between schools and society.

Center for Applied Special Technology
www.cast.org/stsstudy.html
"The Role of Online Communications in Schools: A National Study" isolates the impact of online use and measures its effect on student learning in the classroom. The study compares the work of 500 students in fourth-grade and sixth-grade classes in seven urban school districts.

Committee for Economic Development
ced.org
Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education (Washington, D.C.: Committee for Economic Development, 1995) offers examples of how teachers can use computer technology to improve math and science learning, and recommends strategies for designing budgets and technology programs.

Cuban, Larry
How Teachers Taught: Constancy and Change in American Classrooms, 1880-1990 (New York: Teachers College Press, 1993) explores why the traditional, teacher-centered classroom has endured despite various efforts at reform over the past century.

Teachers and Machines: The Classroom Use of Technology since 1920 (New York: Teachers College Press, 1986) focuses on how movies, telephones, and television failed to produce significant education reform despite the high hopes of their advocates.

"Computers Meet Classroom: Classroom Wins," in *Teachers College Record*, volume 95, number 2 (winter 1993): 184–210, is a fascinating discussion of how computers, too, could fail to change the structure of classrooms.

EdWeb
edweb.cnidr.org
EdWeb contains very useful and accessible explanations of the development of the Internet and its relationship to education reform. EdWeb also has an Education Resource Guide and the "WWWEDU" home page, dedicated solely to discussion of the role of the web in education. Written by Andy Carvin and sponsored by the Corporation for Public Broadcasting (www.cpb.org) and the Center for Networked Information Discovery and Retrieval (cnidr.org).

McKinsey & Co.
www.mckinsey.com
"Connecting K–12 Schools to the Information Superhighway" (www.uark.edu/mckinsey) is a report produced in 1995 for the National Information Infrastructure Advisory Council (www.niac-info.org/~niac). It examines the costs, implementation challenges, and potential benefits of wiring classrooms for advanced telecommunications. The report remains one of the best overall estimates of what the entire effort could cost.

National Academy of Sciences
www.nap.edu/readingroom/books/techgap/welcome.html
"Re-Inventing Schools: The Technology is Now" is a clear and well-produced discussion published by the National Academy of Sciences about how computer networking can lead to school reform.

National School Network Testbed
nsn.bbn.com
Organized in 1992 by BBN Corp. and supported by the National Science Foundation, this project involves schools, museums, corporations, network service providers, and others in a collaborative effort to build state-of-the-art networking applications for education. Its "curriculum and instruction desk" lists valuable resources on school reform and curriculum. It also lists a range of interesting school-community projects (nsn.bbn.com/community/projects.shtml).

Reich, Robert
The Work of Nations (New York: Random House, 1991). The former Labor Secretary looks at the challenges schools need to meet in order to educate tomorrow's labor forces.

Roszak, Theodore
The Cult of Information, 2nd ed. (Los Angeles: University of California Press, 1994). Roszak originally published this book denouncing the growing role of computers in education in 1986, but it remains a thoughtful examination of the difference between information and knowledge, and between data collection and wisdom.

Stoll, Clifford
Silicon Snake Oil: Second Thoughts on the Information Highway (New York: Doubleday, 1995). These musings of a disillusioned cybersurfer raise some interesting and important questions about whether the Internet can live up to its reputation in the world of education and in other spheres.

Strong Families, Strong Schools: Building Community Partnerships for Learning
eric-web.tc.columbia.edu/families/strong
This hyper-book, written by Jennifer Ballen and Oliver Moles of the national family initiative of the U.S. Department of Education, helps educators better involve families and communities in the education of their children.

Transportation for the Mind
www.att.com/worldnet/wis/explore/education/ln/webtour/wt1
Compiled by Margaret Riel, an education program design consultant with the company InterLearn, this site introduces the Internet to teachers and others interested in education. The site contains links to projects that reflect the wide range of educational activities currently underway in the online world.

Secretary's Commission on Achieving Necessary Skills (SCANS Report)
What Work Requires of Schools (Washington, D.C.: U.S. Department of Labor, 1991).

U.S. Office of Technology Assessment
Teachers and Technology: Making the Connection (Washington, D.C.: U.S. Government Printing Office, April 1995) discusses in great detail the role of teachers in making technology work for change in schools. This volume, one of the OTA's last publications (the 104th Congress eliminated the agency's funding), is full of information about virtually every issue involving technology in education.

Statistics

Analysis and Trends of School Use of New Information Technologies
www.gse.uci.edu/EdTechUse
This report was prepared for the Office of Technology Assessment. Although dated, it still contains some of the best data available on computers in the classroom. A print version may be ordered from U.C. Irvine for $15. Send a check, payable to "UC Regents," to Philip C. Coates, Department of Education, University of California Irvine, 2001 Berkeley Place, Irvine, CA 92697-5500.

National Center for Education Statistics
www.ed.gov/NCES/pubs/97944.html
Advanced Telecommunications in U.S. Public Elementary and Secondary Schools (Washington, D.C.: U.S. Government Printing Office, February 1997) provides the most up-to-date statistics on how technology is being deployed in schools. The report, prepared by the U.S. Department of Education, offers no analysis but lots of data. Print copies are also available.

Quality Education Data
www.qeddata.com/results.html
While focused on helping corporations better understand the education market, this research company's data is very revealing, especially in terms of how much money schools spend on technology. See also their Education Technology by State chart (www.qeddata.com/sttech.html).

The teaching process

Education Week Online
www.edweek.org
In addition to being an excellent source of articles about education-related issues (both policy and practice), this site maintains a page of Online Education Resources (www.edweek.org/context/hotlist/best.htm), as well as Quality Counts (www.edweek.org/qc/), a report card on the condition of public education in the 50 states. The site is an excellent example of an online publication, including searchable archives of past issues. Articles of note include:

- "Equity Debates in States Shift to Standards and Technology," by Lonnie Harp (March 6, 1996).
- "Techno-reformers and Classroom Teachers," by Larry Cuban (October 9, 1996).
- "When Enough Is Not Enough," by Lewis C. Solmon and Kalyani Chirra (October 9, 1996) discusses technology allotments.

Educom Home Page
www.educom.edu
Though oriented primarily toward higher education, this easy-to-maneuver site from one of the early players in the field provides a wealth of information on education technology. Created in 1964, Educom describes its members as "committed to education that is active and learner-centered, free from traditional constraints of time and space, lifelong and collaborative, cost-effective, responsive, dynamic, relevant, and accessible."

ILTWeb
www.ilt.columbia.edu
The Institute of Learning Technologies, part of Columbia University, documents the impact of networked digital communication and multimedia on education. ILT also sponsors a number of large-scale research projects intended to develop, test, and implement effective pedagogical approaches to the use of new information technology in education. The materials are comprehensive and fascinating, but they can be difficult for the casual reader.

Institute for Learning Sciences
www.ils.nwu.edu
An interdisciplinary research and development center at Northwestern University, ILS is dedicated to transferring innovative education technology from the laboratory to practical applications in businesses, schools, government agencies, and communities. ILS also builds education software for use in multimedia computers. The site includes "Engines For Education," a hyper-book by Roger Shank, ILS director, and Chip Cleary, a graduate student, on the problems with the education system and how to reform it, especially through the use of education technology.

NetTeachNews
www.chaos.com/netteach
This site provides information for and by the K–12 community about applications of advanced networking technologies in teaching and learning.

T.H.E. (Technological Horizons in Education)
www.thejournal.com
An electronic publication focusing on computers and related technologies that improve teaching and learning.

Education reform

Critical Thinking Community
www.sonoma.edu/cthink
Promotes interdisciplinary education reform. Central to its books, conferences, assessment tools, and workshops is the promotion of quality reasoning, writing, and reading for K–12 schools and universities.

Engines for Education
www.ils.nwu.edu/~e_for_e
A hyper-book about what's wrong with the education system, how to reform it, and especially about the role of educational technology in that reform.

From Now On
www.fromnowon.org
A provocative education technology journal produced by Jamieson McKenzie, director of media and technology for the public school system of Bellingham, Washington. Noteworthy articles include:

- "The Internet As Curriculum," January 1997
- "The Disneyfication of History: Why Books, Libraries, and Librarians Remain Essential," November 1996
- "The Post-Modern School in the New Information Landscape," October 1996

Hodas, Steven
www.review.com/steven/techrefusal/techrefusef.html
In his essay "Technology Refusal and the Organizational Culture of Schools," Hodas, a school and communications analyst who at one time worked on the NASA K–12 Internet initiative, argues that "machines can indeed change the culture of organizations, even ones as entrenched and recalcitrant as schools. But they do it not, as technologists have generally imagined, by enabling schools to do the same job only better (more cheaply, more efficiently, more consistently, more equitably), but by causing them to change their conception of both what it is they do and the world in which they do it."

Means, Barbara, and others
Using Technology to Support Education Reform (Washington, D.C.: U.S. Government Printing Office, 1993). Prepared for the U.S. Department of Education's Office of Research, this volume explains the pedagogical theories behind the current school reform movement, describes the various uses of education technologies, surveys research findings on the impact of technology in classrooms, and discusses how reforms can succeed or fail.

North Central Regional Educational Laboratory (NCREL)
www.ncrel.org/ncrel
One of 10 regional education laboratories financed by the U.S. Department of Education. The site offers a useful essay discussing how changes in the nature of the economy require a different approach to schooling. Although the paper, "Preparing Students for Work in the 21st Century," does not deal directly with computer networking, it explores what students need to succeed in the Information Age. From the NCREL home page, click on "Pathways to School Improvement" and then on "school to work."

Selected Research on School Reform
www.slonet.org/global/education/res7.html
Compiled by SLONET, a California nonprofit providing a regional information access network for San Luis Obispo and Northern Santa Barbara counties in California.

Equity

Federal Communications Commission
www.fcc.gov
1919 M Street NW, Washington, DC 20554; 202/418-0200. The FCC is an independent government agency responsible for regulating interstate and international communications by radio, television, wire, satellite, and cable. It also provides communications-related materials, including universal service proposals, information on discounts for schools and libraries, calendars for hearings, decisions on regulations, and instructions for how to file comments in FCC proceedings.

Krieg, Richard
"Information Technology and Low-Income, Inner City Communities," in *The Journal of Urban Technology*, volume 3, number 1, fall 1995. In a useful overview, the article illustrates how inner cities are cut off from public institutions, resources, and communications tools. Krieg also charts different types of technology applications that could be used to remedy inner-city residents' isolation.

Milone, Jr., Michael N., and Judy Saltpeter
"Technology and Equity Issues," in *Technology and Learning* (January 1996): 38. Also available at alliance.ed.uiuc.edu/iaes/list-archive/1995-96/IAES_1995-96_94.html.

The Next Generation of Universal Service: Discounts for Schools and Libraries
www.benton.org/Library/Nextgen/discounts.html
Published by the Benton Foundation, Washington, D.C., this report presents the Federal-State Joint Board on Universal Service's proposals to the Federal Communications Commission on how to implement the Telecommunications Act's universal service provisions, particularly the required discounts for schools and libraries for communications services.

Piller, Charles
"Separate Realities: The Creation of the Technological Underclass in America's Public Schools," in *Macworld* (September 1992): 218–30. After traveling extensively to observe how schools were using computers, Piller came to the chilling conclusion that "in most cases, computers simply perpetuate a two-tier system for rich and poor."

Somerville, Mary R.
"Gateways to Cyberspace: Discounts for Libraries and Schools are an Investment in the Future," in *The Washington Post*, October 23, 1996; page A23. This op-ed by the president of the American Library Association details the important role of schools and libraries in providing Internet access to all citizens and explains the problems of cost that libraries face when trying to provide access. The article was written before the FCC's Federal-State Joint Board on Universal Service made its recommendations, but the discussion on the importance of these public institutions in the digital age and the challenges they face is still pertinent.

Assessment

Center for Children & Technology Education Development Center
www.edc.org/CCT
CCT aims to improve education by altering the circumstances of teaching and learning through basic, applied, and formative research and technology development.

Center for Research on Evaluation, Standards, and Student Testing (CRESST)
www.cse.ucla.edu
Based at the University of California at Los Angeles, this site offers a rich array of reports on research into alternative forms of evaluating student learning. Though not geared exclusively to the role of technology in the classroom, these papers give a detailed view of the theory and practice of "performance-based assessment," which many analysts believe is a key element in school reform. Visitors to the site can order a CD-ROM disk with five years of CRESST research results on it.

ERIC Clearinghouse on Assessment and Evaluation
ericae2.educ.cua.edu
This site seeks to provide balanced information concerning educational assessment and resources to encourage responsible test use.

EvNet: Network for the Evaluation of Education and Training Technologies
socserv2.mcmaster.ca/srnet/evnet.htm
EvNet is a consortium of public, private, and nonprofit organizations that evaluates instructional and training technologies.

Impact on Technology
www.mcrel.org/connect/tech/impact.html
This website provides an online "bibliography" of education technology evaluation and assessment reports available on the Internet, compiled by the Mid-continent Regional Educational Laboratory (McREL).

Quality Education Data
www.qeddata.com
QED is a for-profit company focused on market research, particularly for long-term educational trends. While much of QED's information is available only

to clients, it provides some national trend data on financial investments in educational technology.

Thompson, Ann D., Michael R. Simonson, and Constance P. Hargrave

Educational Technology: A Review of the Research (Washington, D.C.: Association for Educational Communications and Technology, Second Edition, 1996). A comprehensive summary of research findings on the impact of various technologies on student learning. The volume is particularly valuable to the layperson because it puts the research in a broader context, describing how evolving theories about how students learn have shaped ideas about school reform and the use of technology in the classroom. It also pinpoints areas where more research is needed—including qualitative measures of student performance. The volume, as well as numerous other publications, can be purchased for $25 from the Association for Educational Communications and Technology, 1025 Vermont Avenue NW, Suite 820, Washington, DC 20005.

WestEd
www.wested.org

A nonprofit research, development, and service agency dedicated to improving education and other opportunities for children, youth, and adults. Drawing on the best from research and practice, WestEd works with practitioners and policymakers to address issues ranging from early childhood intervention to the school-to-work transition, and from curriculum, instruction, and assessment to safe schools and communities. WestEd was created in 1995 to unite and enhance the capacity of Far West Laboratory (www.fwl.org) and Southwest Educational Development Laboratory (www.sedl.org), two of the nation's original education laboratories (created by Congress in 1966).

Technology planning and implementation

Armadillo's K–12 WWW Resources
chico.rice.edu/armadillo/Rice/Resources/reshome.html

This site maintains a list of Acceptable Use Policies.

Bellingham Public Schools
www.bham.wednet.edu

Bellingham, Washington, has undertaken one of the nation's most comprehensive technology programs. This website includes numerous valuable responses. See especially the sections on board policies and lesson plans for ideas about how one school system defined its educational objectives and went about systematically incorporating them into teacher training, curriculum development, and assessment.

Co-NECT
co-nect.bbn.com/Schools/Info/overview.html

Helps schools and districts use technology for whole-school change and improved academic results. Co-NECT works with schools in communities around the country to revitalize teaching and learning using sustained professional development. The Co-NECT support team includes experienced educators and technology specialists committed to helping teachers, principals, and district officials achieve local educational goals. One of their schools is the Accelerated Learning Laboratory (nis.accel.worc.k12.ma.us).

Developing a School or District Technology Plan
www.ncrel.org/sdrs/areas/issues/methods/technlgy/te300.htm

This multimedia article addresses the issues involved in developing a technology plan. It includes audio interviews with educators about their experiences and pointers to illustrative cases.

National Center for Technology Planning
www.nctp.com
This is a clearinghouse for the exchange of many types of information related to technology planning. Contains school district technology plans, technology planning aids (checklists, brochures, sample planning forms, PR announcement forms), and electronic monographs on timely, selected topics.

Northwest Regional Educational Laboratory
www.ncrel.org/tandl/homepg.htm
This site offers "Learning Through Technology: A Planning and Implementation Guide" to help educators and community members develop a comprehensive learning and technology plan.

Texas Education Network (TENET)
www.tenet.edu/tenet-info/accept.html
TENET has compiled a list of Acceptable Use Policies.

U.S. General Accounting Office
"School Facilities: America's Schools Not Designed or Equipped for 21st Century" (GAO-HEHS-95-95, Washington, D.C., April 1995) summarizes findings of a survey of school administrators' view on their infrastructure needs. The report must be read with a grain of salt because it relies on subjective responses from school officials. But it does indicate that many administrators see serious problems in being able to offer students a safe environment suitable for learning, let alone being able to house sophisticated computer systems.

Developing curricula

Computer as a Learning Partner
clp.berkeley.edu/CLP.html
Educational researchers, natural scientists, middle-school teachers, and technology experts describe a semester-long thermodynamics, light, and sound curriculum for achieving integrated science understanding that involves the innovative use of computers in the classroom. A project of the University of California at Berkeley.

Evaluating World Wide Web Resources
www.science.widener.edu/~withers/webeval.htm
Jan Alexander and Marsha Tate, reference librarians at the Wolfgram Memorial Library of Widener University in Chester, Pa., developed a methodology for evaluating websites for authority, accuracy, objectivity, timeliness, and thoroughness.

Fair Use Guidelines for Education Multimedia
www.libraries.psu.edu/avs/fairuse/guidelinedoc.html
A report adopted by the U.S. Subcommittee on Courts and Intellectual Property, this provides guidance on the application of fair use principles by educators, scholars, and students who develop multimedia projects using portions of copyrighted works under fair use rather than by seeking authorization for noncommercial educational uses.

The Online Educator
www.ole.net/ole
This website includes lesson plans and clear writing dedicated to making the Internet an accessible classroom tool. It is also available as a print magazine.

Roerden, Laura Parker
Net Lessons: Web-Based Projects For Your Classroom (Sebastopol, Calif.: O'Reilly & Associates, 1997). Written by a teacher and curriculum designer, this book and CD-ROM offer guidelines for using the web to enhance curriculum as well as practical implementation plans and an assessment tool for determining the appropriateness of the web for specific goals. They include lessons organized by subject area and level,

and covers alternative environments like home schooling.

Russell School Technology Curriculum
www.columbia.k12.mo.us/rue/curric.htm
This K-5 school published its efforts to integrate technology with all appropriate aspects of its curriculum so that others might benefit from their experience. Sorted by grade, then curriculum goals and themes.

Sample Curriculum-Based K–12 Educational Telecomputing Projects
www.ed.uiuc.edu/Activity-structures
Judi Harris, a professor at the University of Texas at Austin, pulled together this useful sampler of the variety of educational activities underway in the electronic world. Harris describes various interpersonal exchanges, data-gathering efforts and problem-solving projects.

Content for classroom use

AskERIC
ericir.sunsite.syr.edu
This award-winning Internet-based education information service of the ERIC System is headquartered at the ERIC Clearinghouse on Information & Technology at Syracuse University. Teachers, library media specialists, administrators, and others involved in education can send a message requesting education information to AskERIC. AskERIC information specialists, drawing on the vast resources and expertise of the ERIC System, will respond within 48 hours with ERIC database searches, ERIC Digests, and Internet resources. The benefit of the human-mediated service is that it allows AskERIC staff to interact with the user and provide relevant education resources tailored to the user's needs.

Classroom Connect on the Net
wentworth.com/classroom
This handsome and comprehensive website maintained by Wentworth Worldwide Media provides lesson plans, libraries, museums, science projects, and numerous other valuable resources that can be used in the classroom. Wentworth has embarked on an ambitious multimedia publishing program for the K–12 market, including newsletters, books, videotapes, computer software, and seminars.

Committee for the National Institute for the Environment
www.cnie.org
A national online library of scientifically sound information about the environment, including reports by the Congressional Research Service previously unavailable to the general public.

CyberEd
www.ustc.org/CyberEd
As part of the CyberEd project, NCSA (www.ncsa.uiuc.edu/edu/cybered) developed content for the project, including "Exemplary WWW Sites for Students" (www.ncsa.uiuc.edu/edu/cybered/cybered_hotlist.html), and "Resources for Educators and Administrators" (www.ncsa.uiuc.edu/edu/cybered/cybered_indices.html).

Discovery Channel's "Cable in the Classroom"
school.discovery.com
This website includes interdisciplinary programs that can be integrated with classroom curricula. It also includes a library of online resources for each program, including hands-on classroom activities, lesson plans, connections to academic standards, and links to related sites on the web. In addition, a cadre of online educators known as Subject Area Managers lead forum discussions and provide insight on effective use of the programming in the classroom. Educators may also join the Discovery Channel School online mailing list to receive weekly programming updates.

Education First: Wired Learning in the Classroom & Library
www.kn.pacbell.com/wired/wiredApps.html
This collection of lesson plans was prepared by a design team at San Diego State University that was financed by Pacific Bell's "Education First" initiative. It includes web quests described in this report (among many others):

- Nonprofit Prophets (www.kn.pacbell.com/wired/prophets) describes itself as a "telecommunications community-action project." Students connect with nonprofits and experts and learn more about a community or global problem that concerns them. The students then, in partnership with others and working in the field, develop websites and presentations to better educate the community about the problem and potential solutions.
- Searching for China (www.kn.pacbell.com/wired/China/ChinaQuest.html).
- Does the Tiger Eat Her Cubs? (www.kn.pacbell.com/wired/China/childquest.html).

Electric Library
www.elibrary.com
A subscription service containing reference materials produced by well-known and reputable publishers, this site also includes a "natural-language" search system. A related service, also by Infonautics, Inc., is Researchpaper.com (www.researchpaper.com) which includes not only subject-sorted resources, but tips on writing better papers and a chat area.

Encyclopedia Britannica
www.eb.com
Available online for a free seven-day trial. Otherwise it costs $14.95 a month or $150 a year for individuals. Institution rates are also available.

Faces of Science
www.lib.lsu.edu/lib/chem/display/faces.html
An extensive resource list of African American men and women who have contributed to the advancement of science and engineering, compiled by the Chemistry Library at Louisiana State University.

Fairland Elementary's Online Curricula
www.wam.umd.edu/~toh/Fairland.html
Mary O'Haver (highlighted in this report) and other teachers at this school are committed to contributing resources to the web. This site contains almost 200 well-documented student projects and content packaged for a K–6 audience.

The GLOBE Program
www.globe.gov
Launched by Vice President Gore, this site enlists students in measuring environmental phenomena worldwide and then links them to scientists for data analysis and interpretation.

The Jason Project
www.jasonproject.org
The project organizes annual interactive field trips to such locales as a volcano in Hawaii, the Galapagos Islands, and the Mayan ruins. The substantial and award-winning curriculum suggestions and lesson plans stress hands-on activities and multidisciplinary approaches. An online component of the program enables students to exchange notes with explorers at the scene, and to help students participate in actual research with scientists.

Journey Exchange Project
www.csnet.net/minds-eye/journey
This project engages students from grades 3–12 in a planned and researched five-day journey across the world into another student's mind using geographic, social, economic, political, and historical clues.

Content for classroom use

KIDLINK
www.kidlink.org
KIDLINK is a grassroots keypal project that has drawn 37,000 kids from 71 countries into a "global dialogue." For a glowing recommendation, see the Delmar Elementary School home page (www.intercom.net/local/weeg).

KIDS: Kids Identifying and Discovering Sites
rs.internic.net/scout/KIDS
This is a web publication supported by the InterNIC Net Scout project and produced by K–12 students as a resource for other K–12 students. KIDS is an ongoing, cooperative effort of two classrooms in the Madison Metropolitan School District in Wisconsin and two classrooms in the Boulder Valley School District in Colorado. While teachers assist and provide support, the students select and annotate all resources included in every issue of KIDS.

Library in the Sky
www.nwrel.org/sky
From Northwest Regional Educational Laboratory, this site is a meta-list of curriculum and research resources broken down by subject area and by user type (teacher, student, parent, administrator, librarian, community).

The Math Forum
forum.swarthmore.edu
The Math Forum began as an electronic community dedicated to the teaching of geometry and now covers all areas of mathematics. Site highlights include math exercises, Internet workshops for teachers, web-based lessons and classroom materials, and a searchable Internet math resource collection. Used by many K–12 math teachers and students.

The Monster Project
www.csnet.net/minds-eye/whatis.html
This online project was created by parent John Thompson and third-grade teacher Brian Maguire for the K–9 grade level. A student draws an original monster and then communicates that drawing into words using the writing process and the writing skills taught by the teacher. The student from a cooperating school (in many cases located in another country) receives the description and uses reading comprehension skills to try to redraw the original monster.

NASA IITA K–12 Internet Initiative
quest.arc.nasa.gov
This site describes NASA's many educational activities, including online interactive projects, grants programs, assistance in learning to use the Internet in schools, and links to NASA's own online resources. Initiatives include:

- KidSat (www.jpl.nasa.gov/kidsat) brings space exploration into classrooms around the nation. Through the Internet, students are involved in planning observations and using images from Shuttle-based cameras to study Earth's dynamic, fragile environment.
- Liftoff to Space Exploration (astro-2.msfc.nasa.gov) includes a real-time Java clock that's counting down the seconds to the next scheduled liftoff, lots of historical space facts, and word straight-from-the-horse's-mouth about life on Mars.
- The Smithsonian Ocean Planet Exhibit (seawifs.gsfc.nasa.gov/ocean_planet.html). Want to take an online excursion to a current exhibit at the Smithsonian in Washington, D.C.? This handsome, well-organized site offers cyber visitors more information than the actual exhibit does.

National Geographic
www.nationalgeographic.com
The magazine has repackaged its information for convenient classroom use. From the "society" section of their website, educators can access the Geography Education Program, which provides "lessons, units, and activities designed to bring good geography into the class-

room." In this program they have lesson plans from the kindergarten level all the way through the twelfth grade.

Odyssey in Egypt
www.scriptorium.org/odyssey
This site allows middle schoolers to participate in an actual Egyptian archaeological excavation and receive a full multidisciplinary curriculum on Egypt.

Patricia Weeg's Teacher Resources
www.intercom.net/local/weeg/resource.html
Created by a teacher, this website includes a list of online curriculum projects and examples of schools online.

The PBS homepage
www.pbs.org
PBS provides interactive opportunities for the classroom on this site. Programs like "SCIENCELINE" offer elementary school teachers the chance to enroll in a year-long online training program to support them in their efforts to comply with the new science education standards. Also sponsored on the PBS site is "MATHLINE," which helps teachers in elementary and middle schools reach higher goals in mathematics education and achievement.

Prentice-Hall
www.prenhall.com/pubguide
This publisher's site contains many textbooks that they have converted to web format, or provides companion pieces to printed books. For example, Biology: Life on Earth (www.prenhall.com/audesirk) provides an online interface to a world of biology-related resources. It has a quiz feature, web links, news groups, and a great interface for the major Internet search engines.

TERC
www.terc.edu
A nonprofit organization that researches and promotes innovative approaches to math, science, and technology education, TERC maintains a website that describes a variety of projects involving students in collaborative online science investigations. It operates the Hub (ra.terc.edu/HubHome.html), an Internet publication service that disseminates reports, curricula, projects in progress, calendars, articles, and software of value to educators. The Hub concentrates on science and mathematics but has other educational materials as well. (For an annotated list of network resources for K–12 education, see ra.terc.edu/alliance_resources_services/services.html.)

Think Globally
www.thinkglobal.org
Created by Wendy Bay Lewis of the Montana Center for International Visitors, this site includes lesson plans for middle school teachers based on Jimmy Carter's book, *Talking Peace*. Carter's book, about resolving international conflicts, gives young people around the world a new understanding of the civil war in Albania. The site includes an Albania Conflict Report, where students file reports listing points on which opposing sides agree or disagree, and proposals for resolving the conflict peacefully; a World Conflicts Archive (on Chechnya and Peru); and The Electronic Passport, which introduces kids to email and matches them with 15–20 other schools for three weeks to discuss a particular theme (Earth Day, for example).

ThinkQuest
www.advanced.org/ThinkQuest
Some of the best student-produced educational websites were entered into the ThinkQuest contest, and can be found here, including EduStock (portia.advanced.org/3088), a primer and tutorial on the stock market; and Anatomy of a Murder (portia.advanced.org/2760), a trip through the U.S. criminal justice system.

WhaleNet
whale.wheelock.edu
The brainchild of J. Michael Williamson of Wheelock College, this site is an interdisciplinary, hands-on, collaborative monitoring project to foster science education and interest in schools utilizing telecommunications. Through interaction with cooperating scientists and research institutions, students participate in research projects on and use data from the marine ecosystem, including marine mammal identification and migration patterns.

Professional development organizations and projects

National Teacher Enhancement Network
www.montana.edu/~wwwxs
A project of Montana State University supported in part by the National Science Foundation, the network offers graduate-credit science and math telecomputing courses to middle and high school teachers nationwide.

The Online Internet Institute
oii.org
This site offers a national collaborative structure to support local staff development efforts. OII came from the vision of two classroom teachers, Ferdi Serim and Bonnie Bracey, who recognized the need for professional development activities that would help other teachers become part of the Internet community. The OII Entry Points (oii.org/OIIentry.html) and CyberSeminar (oii.org/Onlineagenda.html) enable participants to develop skills in computer basics, connectivity, exploration and evaluation, navigation and research, communication, and curriculum development and presentation. The classroom educators and proponents of systemic reform who created the Online Internet Institute believe that computers and other educational technologies should be used to support, not replace, the teacher.

Project MOST (Missouri Supporting Teachers)
tiger.coe.missouri.edu/~most
Project MOST is a consortium of statewide education leaders planning a program of education reform and technological innovation. Their integrated teacher support system and network infrastructure is designed around the needs of teachers implementing math and science curriculum through problem-based learning and computational science techniques.

Technology and Teacher Education
www.mcrel.org/connect/tech/prodev.html
This site is an online bibliography of electronic publications about professional development and education technology.

Teacher support

Classroom Connect
www.classroom.net/classroom
Classroom Connect includes educational resources on the Internet and opportunities for K–12 educators to interact with colleagues and peers through interactive databases and regularly scheduled online discussions with other educators.

Clearinghouse for Networked Information Discovery and Retrieval (CNIDR)
www.cnidr.org/k12.html
Created by the National Science Foundation to support networked information discovery and retrieval, the site includes a clearinghouse of resources for teachers and students.

The Collaborative Visualization Project (CoVis)
www.covis.nwu.edu
The project comprises thousands of students, more than 100 teachers, and dozens of researchers all working together to find new ways

to think about and practice science in the classroom.

The Educational Resources Information Center (ERIC)
www.aspensys.com/eric
ERIC is a national information system established in 1966 and supported by the U.S. Department of Education. The site contains more than 850,000 abstracts of documents and journal articles on education research and practice. As the sheer volume of the material suggests, this site is for the serious researcher, not the casual reader. Also check out ERIC's Urban Education Web (UEWeb) (eric-web.tc.columbia.edu), dedicated to urban students, their families, and the educators who serve them; and AskERIC (ericir.syr.edu), an award-winning information service that allows students and teachers to ask questions that will be answered by ERIC specialists within 48 hours.

Global Rivers Environmental Education Network (GREEN)
www.igc.org/green
An innovative, action-oriented approach to education based on an interdisciplinary watershed education model, GREEN connects classrooms around the world in cross-cultural partnerships, develops and disseminates educational materials, and provides training to teachers, students, businesses, governments, and community groups.

Harasim, Linda, Starr Roxanne Hiltz, Lucio Teles, and Murray Turoff
Learning Networks: A Field Guide to Teaching and Learning Online (Cambridge, Mass.: MIT Press, 1995). Drawing on the authors' considerable experience with teaching and learning online, this book describes the learning networks that are available as well as new examples of learning networks that can be created.

InfoBits
www.iat.unc.edu/infobits/infobits.html
Published by the Institute for Academic Technology, each month this site monitors and selects information from a number of instruction technology sources and provides brief notes for electronic dissemination to educators.

Institute for Learning Technologies
www.ilt.columbia.edu/k12/livetext
LiveText is a "living textbook" on how to teach with technology, designed to help teachers find what they seek and learn how to use it; and as they do so, discover what else there is that can support them. LiveText also includes model curricula (www.ilt.columbia.edu/k12/livetext/curricula).

International Education and Resource Network (I*EARN)
www.iearn.org/iearn
I*EARN sponsors a variety of learning projects aimed at enabling young people to make meaningful contributions to the health and welfare of their world. I*EARN also offers conferences for teachers and educational managers. One of its better resources for teachers is Margaret Riel's Learning Circle Teacher Guide (www.att.com/education/lcguide), which describes how a team of 6–8 teachers and their classes work together in the virtual space of an electronic classroom. The groups remain together over a 3–4 month period working on projects drawn from the curriculum of each of the classrooms organized around a selected theme.

Internet Primer for Teachers
www.geocities.com/Athens/4610
The primer is an introduction to basic questions about the Internet.

Kathy Schrock's Guide for Educators
www.capecod.net/schrockguide
Maintained by the technology coordinator for the Dennis-Yarmouth Regional School District, the guide lists more than 1,200 websites for educators. Most relate to curriculum, though Schrock is also developing some original content on website calculation. The site gets about 75,000 hits a month.

LabNet
labnet.terc.edu/labnet
LabNet is a forum for K–12 science and math teachers to explore inquiry-oriented, project-based learning. The site offers teachers access to Presidential Awardees, Woodrow Wilson Fellows and other recognized teachers, discussion groups, online collaborative projects, news, and more. LabNet is run by TERC (www.terc.edu) and funded by the National Science Foundation (www.nsf.gov).

Learning and Leading with Technology
www.iste.org/learning/learning.html
This is the web version of a print magazine published eight times per year by ISTE (see Nonprofit organizations, below). It provides practical ideas for using technology in the classroom. A subscription is included in ISTE membership ($58/year).

Learning with the World
edweb.sdsu.edu/edfirst/web_learning/overview.html
Tom March has been designing Internet-based curricula at San Diego State University on a fellowship from Pacific Bell's Education First initiative. This site is his introduction to the potential uses of the Internet in classrooms.

McGuffey's Web WWW (World Wide Web) Tutorial
www.ustc.org/webcourse/webcourse.html
A comprehensive introduction to the World Wide Web that assumes no prior knowledge of the web and is jointly sponsored by McGuffey's Web and TECH CORPS. This site is a freely available resource for training K–12 teachers and students to use this technology effectively in their schools.

Project Homeroom
www.highway1.org/homeroom/homeroom.html
This site is a clearinghouse of teaching resources, including nationwide programs, other clearinghouses, organizations, education-related search engines, services, and journals. It also includes a list of government initiatives and school links by state that highlight model school projects and state resources.

Serim, Ferdi and Melissa Koch
NetLearning: Why Teachers Use the Internet (Sebastopol, Calif.: O'Reilly & Associates, 1996). This publication is all about what teachers and their students are learning online, with stories showing why and how the Internet has become invaluable in the classroom. These educators share how they overcame barriers such as a lack of funds, a skeptical administration, a fearful community, and limited technical support. The book can be ordered online (www.ora.com) and includes a CD-ROM. In addition, the excellent resources mentioned throughout the book can be found at www.songline.com/teachers.

Teachers Helping Teachers
www.pacificnet.net/~mandel
A nonprofit resource by teachers for teachers, compiled by Dr. Scott Mandel, this site includes basic teaching tips and a forum for teachers to share expertise.

TeachNet
www.teachnet.org
TeachNet supports and encourages teachers to be leaders, curriculum developers, mentors and peer coaches, researchers, and policymakers. Sponsored by IMPACT II—The Teachers Network, the site includes teacher-designed, student-centered classroom projects available for immediate use in the classroom, across all subject areas; a list of grants, contests, competitions, and fellowships; and online forums for teachers.

Tech Corps
www.ustc.org
Tech Corps is a national nonprofit organization of technology volunteers dedicated to helping improve K–12 education at the grassroots level through the effective integration of technology with the learning environment.

Twenty-First Century Teachers
www.21ct.org
This is the website of a nationwide volunteer initiative encouraging teachers to work with their colleagues to develop new skills for using technology in their teaching and learning activities. Twenty-First Century Teachers includes an English teacher who develops professional networks online to share innovative curriculum ideas with colleagues, a science teacher who helps students access up-to-the-minute science information from around the world over the Internet, a third-grade teacher's aide who uses multimedia technologies to create exciting learning opportunities, and others.

Web66: A K12 World Wide Web
Web66.coled.umn.edu
A project of the University of Minnesota College of Education and the Center for Applied Research and Educational Improvement, this site is designed to help educators establish their own Internet servers, form links with teachers and students at other schools, and find useful resources on the World Wide Web. Web 66 includes a comprehensive list of schools' websites (internationally), a web cruising "vehicle" for teachers that includes sample projects, management tools, curriculum integration and evaluation tools, and mailing lists for discussion of web use in K–12 school classrooms.

The Well-Connected Educator
www.gsh.org/wce
This is an online publication sponsored by the Global Schoolhouse. Teachers, administrators, parents, and others write about educational technology, join in conversations, and learn from one another.

Internet mailing lists for educators

CNEDUC-L
This list features discussions of computer networks in education, with an emphasis on online resources. Send email to listserv@tamvm1.tamu.edu (that's a number "one" in tamvm1"). In the message body, type: subscribe cneduc-l yourname (that's a lowercase "L" in "cneduc-l").

COSNDISC
This is the public discussion group of the Consortium for School Networking. Send email to listproc@listproc.listproc.net. In the message body, type: subscribe cosndisc yourname.

Ed-Info
www.ed.gov/MailingLists/EDInfo
This mailing list archive of a free information service delivers 2–3 email messages per week from the U.S. Department of Education. Each message features one report or initiative (or other information). To receive announcements via email, send a message to: listproc@inet.ed.gov. In the message body, type: subscribe EDInfo yourfirstname yourlastname.

EdNet
Education and networking discussions take place on this listserv. It is a fairly active list. Send email to listserv@lists.umass.edu. In the message body, type: subscribe ednet yourname.

EdTech
This a broad education technology list. There is a lot of traffic (many messages per day), from technical questions about setting up hardware and software to discussions of best technology uses in the classroom. Send email to listserv@msu.edu. In the message body, type: subscribe edtech yourname. Archives are available at www.h-net.msu.edu/~edweb.

EDU-ONLINE
EDU-ONLINE is an open, moderated discussion list for professionals actively involved in delivering training and education via the Internet. Topics discussed include emerging technologies, online training methodologies, online curriculum development, and other aspects of exploiting the online medium to deliver quality professional development. To subscribe, send email to: edu-online@learnskills.com. In the message body, type: subscribe edu-online yourname.

Edupage
www.educom.edu/web/pubs/edupage.html
This subscription list is a biweekly summary of news relating to technology and education from Educom. See the website for email subscription information.

FCCshare
This is an interactive list for parents, teachers, and others using education technology sponsored by the Federal Communications Commission. Send email to subscribe@info.fcc.gov. In the message body, type: sub FCCshare yourname.

Geoged
Geoged is a geography education discussion list. Send email to listserv@ukcc.uky.edu. In the message body, type: subscribe geoged yourname.

K12admin
K–12 educators discuss educational administration on this very active list (many messages a day). Send email to listserv@listserv.syr.edu. In the message body, type: subscribe k12admin yourname.

K–12 Web Development Mailing List
www.lr.k12.nj.us/site/lenape/k-12.html
This is a nationwide, unmoderated mailing list for students and teachers who are developing web pages. Send email to list@mail.lr.k12.nj.us. In the message body, type: subscribe k12-webdev yourname.

Kidsphere
Kidsphere provides information about online projects and other education-related topics. According to the list manager, "The fundamental idea is to try to set up an international network for the use of children and their teachers. Detailed efforts range from getting individual classes online to planning a grand scheme to link the whole world together." This list is very active. Send email to kidsphere-request@vms.cis.pitt.edu. In the message body, type: subscribe kidsphere yourname. Archives are available at www.psd.k12.co.us/archive/kidsphere.

Memories
World War II survivors share their experiences with schoolchildren. Send email to listserv@sjuvm.stjohns.edu. In the message body, type: subscribe memories yourname.

NCTE-TALK
Topics on the discussion list for the National Council of Teachers of English (NCTE) members tend to be less technical and more pedagogical, with teachers sharing

approaches to learning that work and lessons learned. Send email to listproc@tc.org. In the message body, type: subscribe ncte-talk yourname.

Web66: The Mailing List
Web66.coled.umn.edu
Web use in K–12 school classrooms is discussed on this mailing list. Send email to listserv@tc.umn.edu. In the message body, type: SUBSCRIBE Web66 yourname.

Funding sources

Detweiler Foundation
www.detwiler.org
The foundation has a "Computers for Schools" program that has been providing California schools with computers since 1991.

Edtech-ALERT
www.edtech-alert.com
This site provides educational technology funding news and planning support.

Educational Technology at Far West Laboratory
gopher: gopher.fwl.org
This gopher site includes funding information, distance learning, professional development, legislation and policy, technology planning, and the California Technology Information Project (CalTIP).

Mid-Continent Regional Educational Laboratory (McREL)
www.mcrel.org/connect/tech/funding.html
A bibliography of resources pertaining to educational technology funding is maintained at this site.

National Telecommunications Infrastructure Administration's (NTIA) Telecommunications Information Infrastructure Assistance Program (TIIAP)
www.ntia.doc.gov/tiiap
NTIA makes grants to help organizations make use of the National Information Infrastructure. Check out projects that have won past grants.

Resource Guide to Federal Funding for Technology in Education
www.ed.gov/Technology/tec-guid.html
An extensive list of federal funding opportunities is available on this website.

U.S. Department of Education
Programs:

- Star Schools Program (www.ed.gov/prog_info/StarSchools), created in 1988, is one of the largest networks of public and private sector partners helping to build the capacity of the education community to make effective use of the information highway.
- Technology Innovation Challenge Grants (www.ed.gov/Technology/challenge/97appl.html) will fund projects from alliances of educators, industry partners, and community leaders who are developing creative responses to the Information Age requirements of all learners. During their first year 19 projects served 1.2 million students and trained thousands of teachers.
- Technology Literacy Challenge Fund (TLCF) (www.ed.gov/Technology/TLCF) will enable districts to build on and adapt resources developed with the Innovation Challenge Grants, Star Schools, and other private and public resources. Each state receives an entitlement that is distributed to school districts or consortia of districts and public or private entities to adapt or develop technology programs that incorporate professional development, content-rich programs, and utilize access to the Internet.

Government

Federal

Information Infrastructure Task Force
www.iitf.nist.gov
The interagency IITF was created to articulate and implement the Clinton administration's vision for the National Information Infrastructure. Included on the IITF site is an archive of speeches and testimony regarding the administration's stance on various information technology issues as well as documents and reports produced by various committees and working groups within the IITF.

LearnNet
www.fcc.gov/learnnet
LearnNet is the FCC's informal education page. The FCC is working to bring every school in America into the Information Age. LearnNet contains information about important FCC policy and education initiatives.

NASA's Classroom of Tomorrow
www.cotf.edu
This is a research and development center for educational technologies that provides technology-based tools and resources to K–12 schools.

The National Science Foundation Directorate for Education and Human Resources
red.www.nsf.gov
The NSF is behind some of the most innovative projects to develop computer networking in education, including Common Knowledge: Pittsburgh and the Learning through Collaborative Visualization (CoVis) Project. Also of interest is the division of elementary, secondary, and information education, which describes the NSF's Global Schoolhouse project, with an archive of brief and interesting news about uses of technology in education.

The U.S. Department of Education
www.ed.gov/Technology
The Department of Education's site contains an extensive series of online resources covering topics from education statistics to education reform, technology initiatives, and sources of educational funding from the federal government. Those without web access can write to the U.S. Department of Education, Washington, DC 20202 or call 1-800-USA-LEARN. (See also the Funding Sources section, above.) Individual educational technology initiatives also have their own pages:

- *Getting America's Students Ready for the Twenty-First Century: Meeting the Technology Literacy Challenge* (www.ed.gov/Technology/Plan) is the Department of Education's report to the nation on education and technology in elementary and secondary education. This resource highlights success stories and outlines why the Clinton administration feels that technology is a crucial part of education today. The book also has statistics on what percentage of U.S. schools are connected, estimates on costs, and information on the role of the federal government in supporting technological innovations in the classroom. "The Technology Literacy Challenge" describes specific steps for the integration of technology into education for the country.
- National Center for Educational Statistics (www.ed.gov/NCES) has survey data on issues like percentage of schools with connectivity. In fall 1996 the NCES published "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools," (www.ed.gov/NCES/pubs/97944.html) by Shelley Burns (Shelley_Burns@ed.gov), Heaviside, Riggins, and Harris (Westat, Inc.). The survey took information from public schools on the availability of the Internet and other advanced telecommunications tools for students and

teachers. It documents typical support mechanisms for advanced communications and charts schools' future plans for increasing technology in their programs. Most of the data have been broken down by a school's location (urban, rural, and so on), percentage minority student body, percentage of student body on school-lunch program, geographic region, and size of enrollment.

- Other Department of Education Publications (www.ed.gov/pubs/pubdb.html).

State

If you are looking for information on specific states or just browsing for different models of educational technology initiatives, a good place to start is a state's department of education home page. Most states have a technology section on their website, and their state technology plan is linked off that. Technology plans are a great way to discover such information as how a state is funding its educational technology initiatives, how teacher training is being addressed, and how hardware is purchased. While many state technology plans are on the web, to save your eyes and your printer it may be best to order hard copies from departments of education.

Some individual state projects include:

- **CalTIP** (www.etc.sccoe.k12.ca.us/caltip/caltip.html) is a one-stop information center for educators in California to find out about ways to plan and implement telecommunications resources in classrooms.
- **Illinois State Technology Plan** (www.isbe.state.il.us/ncsa/k12.html) is this state's extensive plan that comes in at 148 or so pages. For copies of the Illinois plan, contact: Cheryl Lemke, Associate Superintendent of Learning Technologies, Illinois State Board of Education (www.isbe.state.il.us), 100 North First Street, Springfield, IL 62777-0001.

See also the Illinois Alliance of Essential Schools (alliance.ed.uiuc.edu/IAES/Resources/resources.html).

- **Massachusetts NetDay** (www.massnetworks.org) is a sophisticated, well-organized, education-reform-focused Netday effort that stands out from many other NetDay activities. Whether you're participating in the national NetDay movement or not, check out how this state could serve as a model to your efforts to bring connectivity into the classroom.
- **The Texas Education Network** (TENET) (www.tenet.edu) has links to the state technology plan, resources for educators, curriculum resources, and information on how to establish a TENET account.
- **Vermont's Technology Plan** (www.acsu.k12.vt.us/vstc/vtstateplan)
- **Virginia Department of Education Division of Technology** (www.pen.k12.va.us/go/VDOE/Technology).

State Education Agencies
www.spa.org/project/edu_legislation/statedoes.htm
Each of the 50 state departments of education provides support in planning, implementation, and assessment of educational technology programs. Increasing numbers of states are now working with their public utilities and service commissions and telecommunications service providers and telephone companies to provide increased access and lower costs to schools. In addition, many states offer grants for regional and local staff development and school-based educational technology grants. The Software Publishers Association maintains the website of state departments listed here.

Yahoo!'s U.S. States
www.yahoo.com/Regional/U_S__States
Yahoo provides another quick way to locate state boards of education or departments of education not found on the sites listed above.

Select the state of your choice, then Government, then Department of Education.

Regional

Common Knowledge: Pittsburgh
info.pps.pgh.pa.us/ckp.html
This project is a collaboration between Pittsburgh public schools, the University of Pittsburgh, and the Pittsburgh Supercomputing Center to develop a scalable networking infrastructure in support of curricular activities and education reform. It is funded by the National Science Foundation and a 1994 National Telecommunications Infrastructure Administration's Telecommunications Information Infrastructure Assistance Program grant. The project is designed "from the bottom up," starting with teachers rather than being imposed by school administrators. The project will examine this technology as a potential model for school interconnectivity in urban settings. The project is well documented, and the site includes a good collection of educational technology research papers and other excellent resources for educators and administrators. The site also includes an extensive collection of appropriate publications (info.pps.pgh.pa.us:80/publications/publications.html).

Council of Chief State School Officers (CCSSO)
www.ccsso.org
The CCSSO is a nationwide, nonprofit organization that provides direct assistance in all areas of education reform to CEOs of each of the state education agencies, territories, and Department of Defense schools. The CCSSO is now helping states in their preparations to assist school districts in their implementation of the Telecommunications Act and is also assisting development of the TLCF State Technology Plans.

National School Boards Association (NSBA)
www.nsba.org
The association conducts an Annual Technology Plus Learning Conference, providing opportunities for educators to see proven, practical ways to bring technology into the schools. The NSBA also maintains online discussion groups where educators can discuss current issues with colleagues.

Regional Educational Laboratories (RELs)
www.ncrel.org
RELs help educators and policymakers solve educational problems in their states and districts, conduct research on educational issues, and provide training for teachers and administrators. Although all of the RELs address technology as an important priority, the North Central Regional Educational Laboratory (NCREL) specializes in technology.

Regional Technology in Education Consortia (R*TECs)
www.rtec.org
Established in 1995, R*TECs work with schools, districts, state departments of education, universities, and others to provide technological support and assistance. Their primary goal is to ensure that technology is used effectively to support education reforms and to integrate technologies into K–12 schools.

Nonprofit organizations

Abell Foundation
www.abell.org/abell
The foundation seeks to effect positive change on Baltimore's societal problems, including a strong focus on programs promoting education reform.

A*DEC Distance Learning Consortium
www.adec.edu
A*DEC is a national consortium of state universities and land grant institutions providing high-quality and economical distance education programs and services using the latest and most appropriate information technologies.

The American Association of School Administrators
www.aasa.org
Founded in 1865, this is the professional organization for more than 16,500 educational leaders across North America and in many other countries. The AASA's four major focus areas are improving the condition of children and youth, preparing schools and school systems for the 21st century, connecting schools and communities, and enhancing the quality and effectiveness of school leaders.

Benton Foundation
www.benton.org
Benton's Communications Policy and Practice work promotes public interest values and noncommercial services for the National Information Infrastructure through research of "best practices," policy analysis, print, video, online publishing, and outreach to nonprofits and foundations. The website contains updated information on communications policy and highlights innovative practices of technology by nonprofit organizations. It also houses an extensive library of public interest communications documents, including the *KickStart Initiative*, a compendium of case studies and recommendations for connecting schools, libraries, and community centers with advanced telecommunications technologies.

Break Away Technologies
www.breakaway.org
This organization is a technology center based in Los Angeles that provides computer and Internet workshops for community members, especially inner-city youth.

Center for Educational Leadership & Technology
www.celt.org
The center is a nonprofit organization whose primary mission is to integrate technology with current education reforms and research.

Consortium for School Networking (CoSN)
cosn.org
CoSN provides educators with current information on how to get quick, easy, and cost-effective access to the Internet and online resources, and is the national voice for advocating access to the National Information Infrastructure in schools. The website also includes online discussion forums for sharing experiences.

Community Technology Centers Network (CTCNet)
www.ctcnet.org
A national network of technology centers, CTCNet is committed to empowering those communities at greatest risk of being left behind on the information superhighway.

CWEIS (Community-Wide Education and Information Services)
www.cpb.org/edtech/cweis
An initiative designed by the Corporation for Public Broadcasting, CWEIS is developing and encouraging free public access to education and information online services, using local public radio and television stations as a nucleus.

EdLinc (Education and Library Networks Coalition)
www.itc.org/edlinc
EdLinc is a coalition of 37 national organizations representing public schools, private schools, and libraries that was formed to represent the viewpoint of schools and libraries in the FCC proceedings dealing with the implementation of the Telecommunications Act of 1996. The coalition seeks to expand the use of educational technologies in schools and to help educators and others to work locally and nationally to make sure that schools and libraries are given the affordable rate that is guaranteed to them in universal service provisions of the Act.

Foundation for Educational Innovation
1429 G Street NW, Suite 349, Washington, DC 20005, ph: 202/628-6660, Archie Prioleau, president. Created by Archie Prioleau, a former IBM employee, this TIIAP–grant-supported organization promotes technology projects in Washington, D.C., schools.

The George Lucas Educational Foundation—Learn & Live
George Lucas Educational Foundation, P.O. Box 3494, San Rafael, CA 94912, ph: 415/662-1600, fax: 415/662-1605. The George Lucas Educational Foundation (GLEF), located in Nicasio, California, was established as a tax-exempt, charitable organization in 1991 as part of the filmmaker's commitment to finding ways to improve education. Learn & Live is an hour-long documentary, hosted by Robin Williams, aimed at giving the viewer an in-depth look at our nation's educational system. In addition to highlighting major reform issues like technology integration and family involvement, the documentary also shares success stories from some of the pioneer efforts in the field. The foundation has copies available for ordering.

To order Learn & Live, send a note requesting a copy of Learn & Live along with a check or money order for $20 (California residents add $1.65) payable to: The George Lucas Educational Foundation, PO Box 672, Santa Rosa, CA 95402. For credit card orders, call: 1-888-4RKIDS1.

Global SchoolNet Foundation
www.gsn.org
The foundation is a nonprofit corporation launched by a group of San Diego teachers more than 10 years ago that conducts and offers assistance to teachers in designing collaborative learning projects. The foundation also helps schools and other institutions develop telecomputing plans; publishes articles, and disseminates model lesson plans, training materials, and instructional videos; provides newsgroups and discussion lists for classroom use; offers workshops and training; and coordinates conferences using desktop computers.

The Institute for the Transfer of Technology to Education
www.nsba.org/itte
An arm of the National School Boards Association, the institute works actively with school districts across North America that are exploring creative ways to teach and learn with technology.

Instructional Telecommunications Council
www.sinclair.edu/communit/itc
The council is a national nonprofit organization of educators and others involved in higher education, telecommunications, and distance learning.

International Society for Technology in Education (ISTE)
www.iste.org
ISTE promotes appropriate use of technology to support and improve teaching and learning. Its resources include curriculum for learning

about technology and integrating it into the classroom; research results and project reports; and leadership for policies affecting educational technology.

Museums

Each of the following museum-based websites has great pages for kids and educators. The sites contain everything from a step-by-step tour of a virtual beating heart to interactive webzines on Latino artists to tips for teachers on how to have a good museum visit. Each site also contains excellent sections of other online resources.

- **The Exploratorium**, San Francisco, Calif. (www.exploratorium.edu)
- **The Franklin Institute**, Philadelphia, Penn. (www.fi.edu)
- **National Museum of American Art**, Washington, D.C. (www.nmaa.si.edu)
- **Metropolitan Museum of Art**, New York, N.Y. (www.metmuseum.org)

National Audubon Society
www.audubon.org

The Audubon Society is an example of a nonprofit whose resources and expertise are more readily available because of information technologies. Visitors to the site can learn more about Audubon's efforts to preserve wildlife sanctuaries, take a virtual tour of Corkscrew Swamp Sanctuary, or find out how to order Audubon Adventures, a curriculum packet for fourth-, fifth-, and sixth-graders on birds and wildlife habitats that comes with a teacher's manual, CD-ROM, and a subscription to an Audubon Adventures newsletter.

National Coalition for Technology Education and Training (NC-TET)
www.nctet.org

This site includes more than 50 education associations, businesses, and government agencies that serve as a national clearinghouse, with a focus on national technology and telecommunications policy, legislation, and current issues.

National Education Association
www.nea.org

The National Education Association is a strong advocate for technology and telecommunications that promotes the need for teacher-staff development in the effective use of technology.

NetDay
www.netday.org

NetDay is a grassroots volunteer initiative to wire the nation's schools.

Plugged In
www.pluggedin.org

A nonprofit technology center in East Palo Alto, California, Plugged In provides a predominantly minority community with technology and work-related skills.

Corporate players

Ameritech, Inc.
www.ameritech.com/news/contributions/education/investment

This is the address for Ameritech's Investments in Solutions for Education page. From this site, information is available on Ameritech's "Super School" program as well as their other education-related initiatives.

Apple Computer, Inc.
education.apple.com

This site is full of information on Apple's extensive education program. Also check out the Apple Classroom of Tomorrow (www.atg.apple.com/go/acot) website, which includes brief summaries of the reports conducted by the ACOT research unit.

AT&T Learning Network
www.att.com/learning_network

From this page of the AT&T website, interested parties can learn about the company's involvement in connecting communities to the Internet. Information on AT&T's Learning Points program is easily accessible to those interested in either donating points or registering

their schools so that they can reap the benefits of the program.

Autodesk
www.autodesk.com/foundation
This site contains general information about the company's foundation as well as specifics about partnerships with local school districts, including TinkerTech (www.autodesk.com/foundation/tinkertech/tinker.htm), a network of 16 schools exploring project-based learning.

Bell AtlanticCorp
www.bell-atl.com/educate
This site connects to speeches by Bell Atlantic CEO Ray Smith on the importance of connecting schools to the web, and provides links to press releases and information on the company's involvement in wiring educational institutions for Internet access.

Cable News Network's CNN Plus
cnnplus.cnn.com
This site includes a section with links to more than 10 education-related sites and articles on controversial issues like the debate over bilingual education and how schools that have been wired should use new technologies.

Cox Communications
www.cox.com/education.html
Check out this site for information on their "Cable in the Classroom" and distance learning programs as well as the "Multimedia Academy Summer Institute."

Farallon Communications
www.farallon.com/www/education
This site is Farallon's main education page. From here one can find information on all of Farallon's grant and education technology initiative programs.

Genentech's Access Excellence: A Place in Cyberspace for Biology Teaching & Learning
www.gene.com/ae
Connecting high school biology teachers with scientists, other colleagues, and sources of scientific information, this well-organized, searchable site has listings of classroom activities, articles on current science news, and active discussions on many topics. It also contains a Resource Center that lists other relevant websites by subject.

Hewlett Packard Mentor Program
mentor.external.hp.com
This program offers to connect its employees to students in an email mentoring program.

IBM's Reinventing Education
www.ibm.com/IBM/ibmgives/k12ed/k-12init.html
This site describes Big Blue's Reinventing Education and other educational technology initiatives.

Microsoft Corporation
www.microsoft.com/education/k12
Microsoft's education site details various activities involving primary and secondary education. The discussion on school curriculum is interesting, though it focuses primarily on Microsoft's own products rather than dealing with the topic generally.

Netscape Communications
www.netscape.com/comprod/busines_solutions/education
This address leads to Netscape's "Education Solutions" page. Worth noting are the sections titled, "Education Program News" and "Community Projects." Also see K-12 World (www.k-12world.com), sponsored by Netscape.

Pacific Telesis's Education First Initiative
www.pactel.com/community/voices/ed_first/ed-chall.html
This initiative includes a background and resources section for those interested in the issues affecting California schools and libraries and the corporate role in addressing them.

Scholastic, Inc.
www.scholastic.com
From the company that brought you *Highlights for Children* and the Arrow book club comes a website designed to help teachers and administrators get children excited about learning. On the home page, teachers can enter the "free for teachers" section to access information about Scholastic book clubs, book fairs, and the Scholastic software club. In addition to the "free" section, Scholastic also has a part of their home page dedicated to the "Scholastic Network," which they call "the most effective and comprehensive online educational subscription service of teachers and students in elementary and middle schools." Although there is a charge for becoming a member of the network, the quality of the information may be worth it. A 14-day trial membership makes it, at the very least, worthwhile to examine whether or not one joins.

Software Publishers Association
www.spa.org/project/educator.htm
The site provides an extensive list of resources for educators, including educational software evaluation, copyright policies, and relevant federal and state educational technology legislation.

Sun Microsystems
www.sun.com/corporateoverview/CorporateAffairs/ogp_home.html
From this site, Sun provides information on its "Open Gateways Program," which provides hardware, software, and technical support to K–12 schools.

Schools cited in this report

Bellingham School District
www.bham.wednet.edu
1306 Dupont
Bellingham, WA 98225
Ph: 360/676-6400
Dr. Dale E. Kinsley, Superintendent
Dr. Jamieson McKenzie, Director, Instructional Technology and Library/Media Services
Mr. Jim Stevens, Director, Business and Finance

Belridge Elementary School
19447 Wagon Wheel Road
McKittrick, CA 93251-9715
Ph: 805/762-7381
Mr. Steve Wentland, Superintendent
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Cayuga Heights Elementary School
110 East Upland Road
Ithaca, NY 14850
Ph: 607/257-8557

Centennial Middle School
bvsd.k12.co.us/schools/cent/
2205 Norwood Avenue
Boulder, CO 80304
Ph: 303/443-3760
Joseph Sleeper, Principal

Chico High School
www.chs.chico.k12.ca.us/
901 Esplanade
Chico, CA 95926

Clarke Middle School
clarke.ci.lexington.ma.us/
Stedman Road
Lexington, MA
Ph: 617/861-2450
Pamela B. Houlares, Principal

Clear View Charter School
intergate.cvesd.k12.ca.us/cview/cviewhp.htm
455 Windrose Way
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Ginger Hovenic, Principal
(ginger6730@aol.com)
(See also an excellent article in *Education Week* at www.edweek.org/qc/indicators/cli-s.htm, and an article by Ms. Hovenic for the George Lucas Education Foundation at glef.org/glhttp/newsletter/4.2/hovenic.html.)

Cranford High School
nj5.injersey.com/~blasucci
201 West End Place
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Ph: 908/709-6272
Michael D. Blasucci, Principal
Carol A. Fedoryk, Teacher
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Anatomy of a Murder
(tqd.advanced.org/2760)

Delmar Elementary School's Global Classroom
www.intercom.net/local/weeg
700 South 2nd Street
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Ph: 410/896-2780
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www.morsehs.com
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Shirley Peterson, EdD, Principal
John Shacklett, Technology Coordinator

Oak Harbor School District
www.bham.wednet.edu/mod8cly.htm

St. Ambrose Catholic School (formerly Rosa Parks Elementary)
www.stambrose.org
4506 Park Heights Avenue
Baltimore, MD 21215
Ph: 410/664-2373
Fax 410/664-0875
Joanne Rojas, Principal
(Joanne.Rojas@StAmbrose.org)

Sunnyside Elementary School
www.psd267.wednet.edu/ses/seshome.html
425 SW Shirley Street
Pullman, WA 99163
Ph: 509/334-1800
Kristi Rennebohm Franz, Teacher
(sunnyside@agc.apc.org)

Winston Churchill High School
mcps.k12.md.us/schools/churchillhs
11300 Gainsborough Road
Potomac, MD 20854
Ph: 301/469-1221
Mr. Headman, Principal
EduStock project
(tqd.advanced.org/3088)

KIDS

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Are you...

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- A new parent investigating your child care options?
- A business person interested in how a family-friendly workplace affects your bottom line and the future of our youngest children?

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- *Get Smart* with facts on these issues
- *Get Connected* to organizations and communities working for children.

PHONE
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www.kidscampaigns.org